1848

REIS AND BOURSEUL PUBLICATIONS.

1849

CONTENTS.

BOURSEUL PUBLICATIONS.

PAGE

No. 1. *L'Illustration, Journal Universal*, August 26, 1854, a newspaper published in Paris, France. A communication from Charles Bourseul, 1

No. 2. *Didaskalia, Blätter für Geist, Gemüth und Publicität* (Magazine for Intelligence, Humor and News), No. 232, September 28, 1854, a periodical published at Frankfort-on-the-Main, Germany. Apparently an abstract of the foregoing Bourseul article 4

No. 3. *Exposé des Applications de l'Electricité*, by Du Moncel, Paris, vol. 2, p. 225, ed. 1854; vol. 3, p. 110, ed. 1856. Reprint of the body of Bourseul's communication to *L'Illustration* 6

No. 4. *Comptes Rendus des Séances de l'Académie des Sciences*, for November 26, 1877, Paris. Extract from paper about Bourseul and Bell, read before the Academy by Du Moncel 8

No. 5. *The Telephone, the Microphone and the Phonograph*, by Du Moncel, published in French at Paris, in 1878, and in English by Harper Bros., New York, 1879, pp. 12–15 8

REIS PUBLICATIONS.

No. 6. *Frankfurter Conversationsblatt*, November 29, 1861. "Reproduction des Schalles durch den galvanischen Strom" (Frankfurt). [It purports to be a report of Reis's Lectures of October and November, 1861] 10

No. 7. *Jahresbericht des Physikalischen Vereins zu Frankfurt am Main: für das Rechnungs Jahr* 1860–1861 (Yearly Report of the Physical Society at Frankfort-a-M., 1860–1), pp. 57–64 [published in 1862]. "On Telephony by Means of the Galvanic Current, by Philipp Reis." [Reis's lectures re[illegible] by himself] 11

No. 8. *Jahresbericht des Physik[illegible] Vereins zu Frankfurt am Main: für das Rechnungs Jahr* 1861–1862. Extract from the "Proceedings"; being the notice of the two lectures by Reis, October 26 and November 16, 1861 19

No. 9. *Die Fortschritte der Physik*, XVII., for 1861, pp. 171–3 Article entitled "Ph. Reis. Telephony by means of the Electric Current (Annual Report of the Physical Society of Frankfort-on-the-Main, 1860–1, pp. 57–64)". 19

No. 10. *Aus der Natur*, vol. 21, pp. 470–4, Leipzig, 1862. [Abstract of Reis's Lecture of 1861, with quotations from it] 21

1850

PAGE

No. 11. *Didaskalia*, May 8 and May 12, 1862. Extract copied from book of Sylvanus P. Thompson. [Reis exhibitions of May, 1862, before the *Frei Deutsches Hochstift* (Free German Institute)] 27

No. 12. *Zeitschrift des Deutsch-Oesterreichischen Telegraphen Vereins*, Berlin (Journal of the German-Austrian Telegraph Association), vol. 9, p. 125, 1862. Legat Article 29

Nos. 13, 14, 15. *Deutsche Industrie Zeitung* (Industrial Gazette), 1863, *Chemnitz*. Three articles from different numbers: No. 16, p. 184, April 17, 1863; No. 18, p. 208, May 1, 1863; No. 22. p. 249; May 29, 1863 . 35

No. 16. Böttger's *Polytechnisches Notizblatt*, 1863, No. 61, p. 81. "On the Transmission of Tones to any desired Distance by means of Electrici y (Telephony)." [Apparently an abstract of the Reis Lecture], 39

No. 17. *Frankfurter Conversationsblatt*, June 30, 1863. [Reprint of the Böttger Article] 42

No. 18. Dingler's *Polytechnisches Journal*, vol. 168, p. 185. [Reprint of the Böttger Article] 42

No. 19. *Polytechnisches Centralblatt*, 1863, pp. 857–9. [Reprint of the Böttger Article] 42

No. 20. *Jahresbericht des Physikalischen Vereins zu Frankfurt-am-Main; für das Rechnungs Jahr* 1862–1863, p. 35 (Report of the Physical Society of Frankfort-on-the-Main). Memorandum of Lecture by Reis, July 4, 1863 42

1869–1870, p. 26. [Mention of the Reis lecture of 1861.]

No. 21. Reis's letter to Ladd, July, 13, 1863. Original in the library of the society; printed in the *Journal of the Society of Telegraph Engineers and of Electricians*, for March, 1883, No. 46 43

No. 22. Report of British Association Meeting, from *The Newcastle Daily Chronicle and Northern Counties Advertiser*, Saturday, August 29, 1863 46

No. 23. *The Civil Engineer and Architect's Journal*, vol. 26, pp. 307–8, 1863. "Acoustic Telegraph," by W. Ladd. A paper read to the British Association, 1863 47

No. 24. Report of the Thirty-third Meeting of the British Association for the Advancement of Science, in August and September, 1863; published in 1864 49

No. 25. Prospectus of J. Wilh. Albert, Frankfort-on-the-Main, August, 1863. 50

No. 26. Reis's Circular of August, 1863 50

No. 27. Reis's Descriptive Circular, 9 August, 1863 52

No. 28. Dingler's *Polytechnisches Journal*, vol. 169, p. 23. Reprint of Legat Article 54

No. 29. Böttger's *Polytechnisches Notizblatt*, 1863, No. 15, p. 225. Böttger's Account of Reis's Improved Apparatus, copied in 54

No. 30. Dingler's *Polytechnisches Journal*, vol. 169, p. 399 54

No. 31. *Die Fortschritte der Physik*, 1863, p. 96 55

No. 32. *Dublin Medical Press*, October 14, 1863 56

No. 33. *Cosmos*. Weekly Encyclopedic Review of the Progress of the Sciences, Paris, Dec. 25, 1863, vol. 23, p. 705. "Note by M. Koenig," 56

1857

PAGE

No. 34. *Zeitschrift des Architectur und Ingenieur Vereins* (Journal of the Society of Architects and Engineers for the Kingdom of Hanover), vol. 12, p. 147. *Dublin Medical Press* Article, condensed 57

No. 35. *Die Gartenlaube* (An illustrated weekly paper of Leipsic), No. 51, December, 1863, "Der Musiktelegraph." Apparently an Abstract of previous articles, with cuts 57

No. 36. *Cosmos*, vol. 24, pp. 349, 352. Published at Paris, March 22, 1864. Long article, purporting to be written from Koenig's establishment . 62

No. 37. *Portefeuille Economique des Machines*, Paris, 1864, vol. 9, p. 101. Second Saint-Edmé article 66

No. 38. *Tagesblait der 39 Versammlung Deutscher Naturforscher*, Giessen, September, 1864. From Sylvanus P. Thompson's book, and there entitled "Extract from the Report of the Germany Naturalists' Society, held at Giessen (1864)" 67

No. 39. *Proceedings of the Literary and Philosophical Society of Manchester.* Published at Manchester, 1865. Notice of Reis's telephone, by Prof. Clifton 68

No. 40. *Annalen du Chemie und Pharmacie*, 1864–65. Foot-note of Buff article 69

No. 41. Koenig's Description of the Reis. From *Koenig's Catalogue des Appareils d'Acoustique*, Paris, 1865, p. 5 69

No. 42. Pisko. *Die neueren Apparate der Akustik*, Vienna, 1865, pp. 94 *et seq.* 70

No. 43. Pisko. *Die neueren Apparate der Akustik*, Vienna, 1865, p. 241. The Reis Prospectus 78

No. 44. *Handbuch der Angewandten Elektricitätslehre*, Von Karl Kuhn, 1865, pp. 1017-21 80

No. 45. Hessler's Description of Reis. Hessler's *Lehrbuch der technischen Physik* (Technical Physics), Vienna, 1866, vol. 1, p. 648 . . . 85

No. 46. Albert's Catalogue of 1866. *Catalogue of J. Wilh. Albert*, Mechanician at Frankfort-on-the-Main, 1866 87

No. 47. "*Electricity*," by Robert M. Ferguson, Edinburgh and London, 1867, p. 257 87

No. 48. *Lehrbuch der Physik und Meteorologie* (Text-book of Physics). *Von Joh. Müller. Siebente Auflage, Zweiter Band*, 1868, pp. 386-389. . 89

No. 49. *The Manufacturer and Builder*, May, 1869, vol. 1, No. 5, pp. 129, 130. Article by Dr. Van der Weyde 92

No. 50. *The Telegrapher*, vol. 5, No. 39, New York, 1869. [Reprint of Van der Weyde's Article] 96

No. 51. American Association on Reis. Paper read by Dr. Van der Weyde at meeting of the American Association for the Advancement of Science, at Salem, August, 1869 96

No. 52. *Boston Daily Advertiser*, Aug. 25, 1869. Notice of the foregoing meeting 97

No. 53. *The Wonders of Electricity.* Translated from the French of J. Baile. New York: Scribner, Armstrong & Co., 1872; pp. 140-143. . . 97

No. 54. Zöllner's *Das Buch der Erfindungen, Gewerbe und Industrien* (Book of Inventions, Trades and Industries); Leipsic, 1872 . . . 99

1850

PAGE

No. 11. *Didaskalia*, May 8 and May 12, 1862. Extract copied from book of Sylvanus P. Thompson. [Reis exhibitions of May, 1862, before the *Frei Deutsches Hochstift* (Free German Institute)] 27

No. 12. *Zeitschrift des Deutsch-Oesterreichischen Telegraphen Vereins*, Berlin (Journal of the German-Austrian Telegraph Association), vol. 9, p. 125, 1862. Legat Article 29

Nos. 13, 14, 15. *Deutsche Industrie Zeitung* (Industrial Gazette), 1863, *Chemnitz*. Three articles from different numbers: No. 16, p. 184, April 17, 1863; No. 18, p. 208, May 1, 1863; No. 22. p. 249; May 29, 1863 . 35

No. 16. Böttger's *Polytechnisches Notizblatt*, 1863, No. 61, p. 81. "On the Transmission of Tones to any desired Distance by means of Electrici y (Telephony)." [Apparently an abstract of the Reis Lecture], 39

No. 17. *Frankfurter Conversationsblatt*, June 30, 1863. [Reprint of the Böttger Article] 42

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No. 20. *Jahresbericht des Physikalischen Vereins zu Frankfurt-am-Main; für das Rechnungs Jahr* 1862-1863, p. 35 (Report of the Physical Society of Frankfort-on-the-Main). Memorandum of Lecture by Reis, July 4, 1863 42

1869-1870, p. 26. [Mention of the Reis lecture of 1861.]

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No. 22. Report of British Association Meeting, from *The Newcastle Daily Chronicle and Northern Counties Advertiser*, Saturday, August 29, 1863 46

No. 23. *The Civil Engineer and Architect's Journal*, vol. 26, pp. 307-8, 1863. "Acoustic Telegraph," by W. Ladd. A paper read to the British Association, 1863 47

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No. 25. Prospectus of J. Wilh. Albert, Frankfort-on-the-Main, August, 1863. 50

No. 26. Reis's Circular of August, 1863 50

No. 27. Reis's Descriptive Circular, 9 August, 1863 52

No. 28. Dingler's *Polytechnisches Journal*, vol. 169, p. 23. Reprint of Legat Article 54

No. 29. Böttger's *Polytechnisches Notizblatt*, 1863, No. 15, p. 225. Böttger's Account of Reis's Improved Apparatus, copied in 54

No. 30. Dingler's *Polytechnisches Journal*, vol. 169, p. 399 54

No. 31. *Die Fortschritte der Physik*, 1863, p. 96 55

No. 32. *Dublin Medical Press*, October 14, 1863 56

No. 33. *Cosmos*. Weekly Encyclopedic Review of the Progress of the Sciences, Paris, Dec. 25, 1863, vol. 23, p. 705. "Note by M. Koenig," 56

1857

PAGE

No. 34. *Zeitschrift des Architectur und Ingenieur Vereins* (Journal of the Society of Architects and Engineers for the Kingdom of Hanover), vol. 12, p. 147. *Dublin Medical Press* Article, condensed 57

No. 35. *Die Gartenlaube* (An illustrated weekly paper of Leipsic), No. 51, December, 1863, "Der Musiktelegraph." Apparently an Abstract of previous articles, with cuts 57

No. 36. *Cosmos*, vol. 24, pp. 349, 352. Published at Paris, March 22, 1864. Long article, purporting to be written from Koenig's establishment . 62

No. 37. *Portefeuille Economique des Machines*, Paris, 1864, vol. 9, p. 101. Second Saint-Edmé article 66

No. 38. *Tagesblait der 39 Versammlung Deutscher Naturforscher*, Giessen, September, 1864. From Sylvanus P. Thompson's book, and there entitled "Extract from the Report of the Germany Naturalists' Society, held at Giessen (1864)" 67

No. 39. *Proceedings of the Literary and Philosophical Society of Manchester.* Published at Manchester, 1865. Notice of Reis's telephone, by Prof. Clifton 68

No. 40. *Annalen du Chemie und Pharmacie*, 1864–65. Foot-note of Buff article 69

No. 41. Koenig's Description of the Reis. From *Koenig's Catalogue des Appareils d'Acoustique*, Paris, 1865, p. 5 69

No. 42. Pisko. *Die neueren Apparate der Akustik*, Vienna, 1865, pp. 94 *et seq.* 70

No. 43. Pisko. *Die neueren Apparate der Akustik*, Vienna, 1865, p. 241. The Reis Prospectus 78

No. 44. *Handbuch der Angewandten Elektricitätslehre*, Von Karl Kuhn, 1865, pp. 1017-21 80

No. 45. Hessler's Description of Reis. Hessler's *Lehrbuch der technischen Physik* (Technical Physics), Vienna, 1866, vol. 1, p. 648 . . . 85

No. 46. Albert's Catalogue of 1866. *Catalogue of J. Wilh. Albert*, Mechanician at Frankfort-on-the-Main, 1866 87

No. 47. "*Electricity*," by Robert M. Ferguson, Edinburgh and London, 1867, p. 257 87

No. 48. *Lehrbuch der Physik und Meteorologie* (Text-book of Physics). *Von Joh. Müller. Siebente Auflage, Zweiter Band*, 1868, pp. 386-389. . 89

No. 49. *The Manufacturer and Builder*, May, 1869, vol. 1, No. 5, pp. 129, 130. Article by Dr. Van der Weyde 92

No. 50. *The Telegrapher*, vol. 5, No. 39, New York, 1869. [Reprint of Van der Weyde's Article] 96

No. 51. American Association on Reis. Paper read by Dr. Van der Weyde at meeting of the American Association for the Advancement of Science, at Salem, August, 1869 96

No. 52. *Boston Daily Advertiser*, Aug. 25, 1869. Notice of the foregoing meeting 97

No. 53. *The Wonders of Electricity.* Translated from the French of J. Baile. New York: Scribner, Armstrong & Co., 1872; pp. 140-143. . . 97

No. 54. Zöllner's *Das Buch der Erfindungen, Gewerbe und Industrien* (Book of Inventions, Trades and Industries); Leipsic, 1872 . . . 99

PAGE

No. 55. Albert's Catalogue of 1873 101
No. 56. Wiedemann's *Die Lehre vom Galvanismus*, 1874, vol. 2, pages 598, 599 102
No. 57. *Scientific American*, March 4, 1876, Dr. Van der Weyde's second article 103
No. 58. Official report of exhibition at *South Kensington Museum* in 1876, edited by Dr. Rudolf Biedermann, published in 1877. Notice of the Reis apparatus exhibited 106

ARTICLES ABOUT REIS AFTER THE BELL PATENT, AND BEFORE THE MICROPHONE WAS KNOWN.

No. 59. Preece on Reis. *Report of the Forty-seventh Meeting of the British Association for the Advancement of Science, held at Plymouth, in August*, 1877. *On the Telephone, by* W. H. PREECE, Memb. Inst. C. E. etc. . 107
No. 60. Ganot's Description of Reis. *Ganot's Elementary Treatise on Physics*, 8th edition, translated by E. Atkinson, N. Y., 1877, p. 757 . 108
No. 61. Dolbear on Reis. *The Telephone*, by Prof. A. E. Dolbear; Boston, Lee & Shepard, 1877, pp. 99–116 108

1853

PUBLICATIONS RELATING TO BOURSEUL.

No. 1. — L'Illustration, Journal Universel, Paris, August 26, 1854, Vol. XXIV., No. 600, p. 139.

Electric Transmission of Speech. In 1848, a young man, learned but modest, taken from his quiet studies, became a soldier in the army of Africa. But passionately fond of science, and endowed with one of those privileged intelligences which permit their possessor to reach any degree of eminence, he did not despair. "I have no longer my professor," said he, "but I have still my books; they will be my friends, my guides, my consolers."

At length, in 1849, young Charles Bourseul, son of an officer in the army, and himself a soldier in the 43d Regiment, gave to his comrades of the garrison of Algiers a mathematical course, and attracted the attention and the kindly interest of the governor-general of Algeria. No one had recommended this simple soldier to the general; he had been his own recommendation, and the general, recognizing his merit, had generously reached out to him a protecting and friendly hand. This simple incident is a touching tribute to the merit of both the soldier and the general.

To-day, freed from military service, Mr. Charles Bourseul lives at Paris, and he is the author of the curious article which is laid before our readers. We wish for him all the success which he himself dares to anticipate, and we should be happy to see him attach his name to the marvellous discovery of the electric transmission of speech. Electricity has in these late days worked so many miracles; why should it not accomplish this one more, in spite of the Academy, where people treat as foolish, or, when they wish to be polite, as Utopian, everything which has not yet been practically accomplished, — a most encouraging course, it must be confessed, for inventors, for these sublime initiators without whom the Academy would be nothing but a collection of fossils? We repeat it again to encourage the ardor of genius searching for the unknown. They can find nothing here in this Academy of Science except it be an insolent smile. Fulton and so many others have learned it to their

cost. But if you speak to-day to an academician of the steam engine and of the electric telegraph, he will tell you that it was a very simple thing, and if the Academy had been willing to bother itself about it, the discovery would have been made much sooner. Well, most learned doctors, here is a problem. Read the communication of Mr. Charles Bourseul. PAULIN.

BOURSEUL'S COMMUNICATION.

The electric telegraph is based on the following principle: An electric current, passing through a metallic wire, circulates through a coil around a piece of soft iron which it converts into a magnet. The moment the current stops, the piece of iron ceases to be a magnet. This magnet, which takes the name of electro magnet, can thus in turn attract and then release a movable plate (*plaque mobile*) which by its to-and-fro movement produces the conventional signals employed in telegraphy. Sometimes this movement is directly utilized, and is made to produce dots or dashes on a strip of paper which is drawn along by clockwork. The conventional signals are thus formed by a combination of those dots and dashes. This is the American telegraph, which bears the name of Morse, its inventor. Sometimes this to-and-fro movement is converted into a movement of rotation. In that way we have either the dial telegraph used on railroads, or the telegraph used in the government system, which by means of two line wires and two indicating needles reproduce all the signals of the aërial telegraph or semaphore which was formerly used. Suppose, now, that we arrange upon a movable horizontal circle letters, figures, signs of punctuation, etc. One can understand that the principle we have stated can be used to choose at a distance such and such a character, and to determine its movement, and consequently to print it on a sheet of paper appropriately placed for this purpose. This is the printing telegraph.

We have gone still further. By the employment of the same principle, and by means of a mechanism rather complicated, it has been possible to reach a result which at first would seem to be almost a miracle. Handwriting itself is produced at a distance, and not only handwriting, but any line or any curve; so that, being in

Paris, you can draw a profile by ordinary means there, and the same profile draws itself at the same time at Frankfort. Attempts of this sort have succeeded. The apparatus has been exhibited at the London Exhibition. Some details, however, remain to be perfected. It would seem impossible to go beyond this in the region of the marvellous. Let us try, nevertheless, to go a few steps further. I have asked myself, for example, if the spoken word itself could not be transmitted by electricity; in a word, if what was spoken in Vienna may not be heard in Paris? The thing is practicable in this way: —

We know that sounds are made by vibrations, and are made sensible to the ear by the same vibrations, which are reproduced by the intervening medium. But the intensity of the vibrations diminishes very rapidly with the distance; so that even with the aid of speaking tubes and trumpets, it is impossible to exceed somewhat narrow limits. Suppose that a man speaks near a movable disk, sufficiently flexible to lose none of the vibrations of the voice; that this disk alternately makes and breaks the connection with a battery; you may have at a distance another disk which will simultaneously execute the same vibrations.

It is true that the intensity of the sounds produced will be variable at the point of departure, at which the disk vibrates by means of the voice, and constant at the point of arrival, where it vibrates by means of electricity; but it has been shown that this does not change the sounds. It is, moreover, evident that the sounds will be reproduced at the same pitch.

The present state of acoustic science does not permit us to declare *a priori* if this will be precisely the case with syllables uttered by the human voice. The mode in which these syllables are produced has not yet been sufficiently investigated. It is true that we know that some are uttered by the teeth, others by the lips, etc.; but that is all.

However this may be, observe that the syllables can only reproduce upon the sense of hearing the vibrations of the intervening medium. Reproduce precisely these vibrations, and you will reproduce precisely these syllables.

It is, at all events, impossible, in the present condition of science,

to prove the impossibility of transmitting sound by electricity. Everything tends to show, on the contrary, that there is such a possibility. When the application of electro-magnetism to the transmission of messages was first discussed, a man of great scientific attainments treated the idea as Utopian, and yet there is now direct communication between London and Vienna by means of a simple wire. Men declared it to be impossible, but it is done.

It need not be said that numerous applications of the highest importance will immediately arise from the transmission of speech by electricity. Any one who is not deaf and dumb may use this mode of transmission, which would require no apparatus except an electric battery, two vibrating disks and a wire. In many cases, as, for example, in large establishments, orders might be transmitted in this way, although transmission in this way will not be used while it is necessary to transmit letter by letter, and to make use of telegraphs which require use and apprenticeship. However this may be, it is certain that in a more or less distant future, speech will be transmitted by electricity. I have made some experiments in this direction. They are delicate, and demand time and patience; but the approximations obtained promise a favorable result.

CHARLES BOURSEUL.

PARIS, August 18, 1854.

No. 2. — DIDASKALIA, BLATTER FÜR GEIST, GEMÜTH UND PUBLICITÄT, Frankfort on the Main, Germany, No. 232, September 28, 1854.

[Magazine for Intelligence, Humor and News.]

The wonders with which electricity has lately astonished us are about, as it seems, to be increased by a new one, that would not only prepare a great revolution in the electric telegraph as practised up to the present, but would increase its usefulness in an incalculable manner.

It is a question of nothing more nor less than an electric transmission of *the spoken word*. The idea originates with a young and educated, though modest young man, Charles Bourseul, who was a soldier of the African army in 1848, where he attracted the attention of the governor-general by a mathematical course which he

1857

delivered to his comrades of the garrison in Algeria, and he is now living in Paris. Bourseul's problem, of the practicability of which he is completely persuaded, belongs, perhaps, to those discoveries which the scientific world afterwards declares very easy, and which they would gladly make us believe could easily have been discovered much earlier if they had chosen to give themselves the trouble.

As is well known, the principle upon which electric telegraphy is based is as follows: An electric current traversing a metallic wire changes a piece of soft iron in the vicinity of which it passes into a magnet. As soon as the current ceases, the magnetic quality also ceases. This magnet, the electro-magnet, can thus alternately attract or let go a movable plate, which by its movements back and forth produces the conventional signals used in telegraphy. Now it is farther known that all tones are brought to the ear only by vibrations of the air, hence are really nothing more than these vibrations of the air, and that the endless variety of tones depends entirely upon the rapidity and amplitude of the sound waves.

Could there now be invented a metallic plate which should be so movable and pliable that it reproduces all the vibrations of tones (like the air), and should this plate be so connected with an electric current that it should alternately make and break the electric current according to the air vibrations by which it was affected, it would thereby be possible also to arrange electrically a second similarly constructed metal plate, so that it repeated simultaneously exactly the same vibrations as the first plate, and it would then be exactly the same as if one had spoken in the immediate vicinity against this second plate, or the ear would be affected precisely as if it received the tones directly through the first metallic wall. The electric telegraph formerly stamped by the Academy as nonsense is now spread throughout all the world as a common phenomenon; if we question in regard to this new idea of a young physicist the principles of physics, they have not only nothing to offer against the possibility of its being carried out, but its success appears in fact to be more probable than did a short time ago that of the electric telegraph itself. If it be practically carried out, the electric telegraph could be operated by every one. There would be need of no farther device and knowledge than a galvanic battery, two vibrating plates and a metal

wire; without any other preparation the one must talk against one metallic plate, and the other hold his ear near the other plate, and they could converse with each other as if face to face. The young inventor believes in the success of his efforts, and challenges scientific men to prove that the laws of physics contradict the above-mentioned principles, and thereby make the attempt seem impossible. Meanwhile may the affair enjoy in high degree the attention which it is certainly attracting.

No. 3.—Exposé des Applications de l'Electricit , Du Moncel, Paris, Vol. II., p. 225, edition 1854; Vol. III., p. 110, edition 1856.

Electric Transmission of Speech. I have not been willing to give a place in the chapter on electric telegraphy to a fantastic conception of a certain Mr. Ch Bxx, who believes that we may yet be able to transmit speech by electricity, because I might have been asked why by the side of so many remarkable inventions I was willing to class an idea which as presented by its author has not got beyond the condition of a dream. But I ought, to be true to the task which I have undertaken, to mention all of the applications of electricity which have come to my knowledge, and therefore I will here give the information which the author has published up to this time on the subject.

"After the marvellous telegraphs, which can reproduce at a distance handwritings, or even more or less complicated drawings, it may appear impossible to penetrate farther into the region of the marvellous, yet we will try to advance a few steps farther. I have, for example, asked myself whether speech itself may not be transmitted by electricity; in a word, if what is spoken in Vienna may not be heard in Paris? The thing is practicable in this way: —

"We know that sounds are made by vibrations, and are made sensible to the ear by the same vibrations, which are reproduced by the intervening medium. But the intensity of the vibrations diminishes very rapidly with the distance; so that even with the aid of speaking tubes and trumpets, it is impossible to exceed somewhat narrow limits. Suppose that a man speaks near a movable disk, sufficiently flexible to lose none of the vibrations of the voice; that this disk alternately

1879

makes and breaks the currents from a battery; you may have at a distance another disk which will simultaneously execute the same vibrations.

"It is true that the intensity of the sounds produced will be variable at the point of departure, at which the disk vibrates by means of the voice, and constant at the point of arrival, where it vibrates by means of electricity; but it has been shown that this does not change the sounds. It is, moreover, evident that the sounds will be reproduced at the same pitch.

"The present state of acoustic science does not permit us to declare *a priori* if this will be precisely the case with syllables uttered by the human voice. The mode in which these syllables are produced has not yet been sufficiently investigated. It is true that we know that some are uttered by the teeth, others by the lips, etc.; but that is all.

"However this may be, observe that the syllables can only reproduce upon the sense of hearing the vibrations of the intervening medium. Reproduce precisely these vibrations, and you will produce precisely these syllables.

"It is, at all events, impossible, in the present condition of science, to prove the impossibility of transmitting sound by electricity. Everything tends to show, on the contrary, that there is such a possibility. When the application of electro-magnetism to the transmission of messages was first discussed, a man of great scientific attainments treated the idea as Utopian, and yet there is now direct communication between London and Vienna by means of a simple wire. Men declared it to be impossible, but so it is.

"It need not be said that numerous applications of the highest importance will immediately arise from the transmission of speech by electricity. Any one who is not deaf and dumb may use this mode of transmission, which would require no apparatus except an electric battery, two vibrating disks and a wire. In many cases, as, for example, in large establishments, orders might be transmitted in this way, although transmission by electricity will not be used while it is necessary to transmit letter by letter, and to make use of telegraphs which require apprenticeship and long-continued use. However this may be, it is certain that in a more or less distant future,

speech will be transmitted by electricity. *I have made some experiments in this direction.* They are delicate, and demand time and patience; but *the approximations obtained* promise a favorable result."

No. 4. — COMPTES RENDUS DES SÉANCES DE L'ACADÉMIE DES SCIENCES, Paris, November 26, 1877.

[Addition to a paper by Du Moncel, referring to Bourseul's plan.]

However this may be, the fact cannot be concealed that it is Mr. Bell who is the inventor of the telephone, for there is a whole world between a first idea and its definite realization. It is simply because Mr. Bell has made the intensity of the currents which transmit the vibrations of the voice to correspond to the latter in their amplitude and their changes, that the problem has been solved.

No. 5. — THE TELEPHONE, THE MICROPHONE AND THE PHONOGRAPH, Du Moncel (American Edition), Harper Brothers, New York, 1879, pp. 12–15.

"From the telegraphic point of view, however, the problem of transmitting sounds to a distance was far from being solved in this way, and the idea of applying electricity to this mode of transmission naturally arose as soon as the wonderful effects of electric telegraphy were observed, that is, in the years subsequent to 1839. A surprising discovery made in America by Mr. Page, in 1837, and afterward investigated by MM. Wertheim, de La Rive, and others, must also have led up to it; for it was observed that a magnetic bar could emit sounds when rapidly magnetized and demagnetized; and these sounds corresponded with the number of currents which produced them.

"Again, the electric vibrators devised by MM. Macauley, Wagner, Neef, etc., and adapted to produce musical sounds, between 1847–1852, by MM. Froment and Petrina, showed that the problem of transmitting sounds to a distance was not insoluble. Yet, up to 1854, no one had ventured to admit the possibility of transmitting speech by electricity; and when M. Charles Bourseul published in that year a paper on the electric transmission of speech, the idea

1861

was regarded as a fanciful dream. I confess that I myself thought it incredible; and when I produced the paper in the first edition of my account of the applications of electricity, published in 1854, I felt bound to add that the scheme seemed more than doubtful. Yet as the paper was thoughtfully written, I had no hesitation in publishing it, affixing the signature of Ch. B. Events justified this daring idea; and although it did not include the only principle which could lead to the reproduction of articulate sounds, yet it was the germ of the fertile invention which has made the names of Graham Bell and Elisha Gray famous. For this reason I will again quote M. Charles Bourseul's paper."

[*Then follows the Bourseul article as just printed, No. 3, p. 6; after which Du Moncel adds this paragraph:* —]

"This description is certainly not full enough to enable us to discern from it the arrangement which would lead to the solution of the problem, and if the vibrations of the disk at the receiving station were to follow from making and breaking the current at the sending station, under the influence of vibrations caused by the voice, they would only produce musical, and not articulate sounds. Yet the idea was magnificent, as Mr. Preece said, even when he thought it impossible to realize it. Besides, it is easy to see that M. Bourseul himself was not deceived as to the difficulties of the problem, as far as articulate sounds are concerned, for he points out, as we have seen, the difference existing between the simple vibrations which produce musical sounds, and the complex vibrations which cause articulate sounds; but, as he justly said, 'Reproduce at the one end of the line the vibrations of air caused at the other, and speech will be transmitted, however complex the mechanism may be by which it is effected.'"

1862

PUBLICATIONS BY REIS AND OTHERS RELATING TO THE REIS TELEPHONE.

No. 6. — FRANKFURTER CONVERSATIONSBLATT, November 29, 1861.

Reproduction des Schalles durch den galvanischen Strom. Reproduction of sound by the galvanic current.

For this new discovery, which rightly excites the greatest interest, we have to thank Mr. Reis, teacher in Friedrichsdorf. He has succeeded after many experiments in solving, up to a certain point at least, this problem, which up to the present has been considered insolvable.

Of all the new discoveries in natural science, there are none of so general advantage and which so enter into our practical life as those in the domain of chemistry and physics; in the latter, galvanism in its application to electro-plating and telegraphy has achieved remarkable results. At the moment when telegraphy has attained a place in our social life, there begins, perhaps, for the same a new era in the fact that as we in telegraphy make ourselves understood by means of signs, in this we can make ourselves understood by means of tones at a distance.

Mr. Reis has constructed in a very ingenious manner an apparatus by means of which he has shown some perfectly successful experiments before a large audience in the Physical Society in this city.

He has made a very happy use of the earlier discovery that the iron core of a wire helix produces tones by the interruptions of the current following each other at very short periods.

His apparatus for receiving the sound is based upon the arrangement of the human ear. It consists in the first place of a funnel-shaped cavity [to represent the cartilage of the ear] to receive the sound, closed at its narrower part by a membrane, upon which is fastened an elastic strip of platinum which is connected with one of the circuit wires, while the former is in electric connection with the other pole of the battery.

As soon, then, as the sound waves set the membrane in vibration, the elastic strip of metal fastened to the same will make the same vibrations, will alternately rise and fall, thereby touching the other elastic strip and so making and breaking the current.

The reproduction of the sound by the galvanic current, for it is only such and not a conduction of the sound, is brought about in the manner specified above. Into a wire helix, included in the circuit, is placed a thin metal rod, — *e. g.*, a knitting needle, — which apparatus, in order to increase the tone, is placed upon an easily vibrating support, a resonant box. By means of the current now made, now broken, the iron rod is also set into vibrations, which are communicated to our ear and there reproduce the sound.

The vibrations of the iron rod correspond with those of the membrane; but as the pitch of the tones is dependent upon the times of vibration of the sounding body, the lower tones escape our notice, while the higher ones are especially noticed.

Up to the present the reproduction of the tones is indeed weak, and words cannot be reproduced. We leave here the question as to whether this hereafter will be successfully accomplished.

Mr. Fritz, instrument maker, has just constructed a new instrument with some improvements, and Prof. Böttger will hereafter make experiments with it in the Physical Society, to which we shall at times call attention.

No. 7. — Jahresbericht des Physikalischen Vereins zu Frankfurt am Main, für das Rechnungs Jahr 1860–1861. Published in 1862.

[Yearly Report of the Physical Society at Frankfort-a-M., 1860-61, pp. 57–64.]

"On telephony by means of the galvanic current, by Philipp Reis."

The extraordinary results in the field of telegraphy have probably often raised the question, If it might not be possible to transmit musical tones themselves [Tonsprache] to a distance? Experiments made in this direction could not, however, produce any result at all satisfactory, because the vibrations of sound-conducting media soon lose their intensity to such an extent that they are no longer appreciable by our senses.

1864

A reproduction of tones [Tonen] at certain distances by means of a galvanic current has probably been thought of, but the practical solution of this problem has certainly seemed the most doubtful to the very persons who, from their knowledge and appliances, were in the best condition to attack it. To a person having only a superficial knowledge of physics, the problem presents far less difficulties, simply because the most of them are unperceived. About nine years ago I also (having an extraordinary enthusiasm for what was new, and an insufficient knowledge of physics) had the boldness to attempt the solution, but was soon forced to desist, because the very first experiment convinced me of the impossibility of its solution.

Later, after further study and experience, I came to see that my first experiment had been a very rough and by no means conclusive one; I did not, however, follow up the subject seriously, because I did not feel myself equal to the difficulties in the way.

Youthful impressions, however, are strong, and therefore not easily effaced. I could never get rid of the thought of that first experiment and its occasion, notwithstanding all that reason says to the contrary, and thus, half unwillingly, this project of my youth was reviewed in hours of leisure; the difficulties and the means for overcoming them were weighed; but for the present, at least, no experiment was made.

How indeed could a single instrument reproduce the combined effect of all the organs occupied in human speech? This was always the cardinal question; finally I got the notion of putting the question in another way, —

How is *our ear* affected by the totality of vibrations produced by the organs of speech all simultaneously active? Or more generally, —

How are we affected by the vibrations of several simultaneously sounding bodies?

To answer this question, we must, in the first place, understand what must happen in order that we may perceive a single tone.

Without our ear, any tone is nothing else than a recurrent condensation and rarefaction of some body repeated at least seven or eight times in a second. If this occurs in the same medium in which we are, the membrane of the ear is at each condensation forced towards

1865

the middle ear, to be moved at the subsequent rarefaction in the opposite direction. These vibrations produce a synchronous raising and falling of the hammer upon the anvil (according to other authorities, an approach or receding of the ear-bone particles), and a similar number of tremors in the fluid of the cochlea, in which the filaments of the auditory nerve are distributed. The greater the condensation of the sound-conducting medium at any given moment, the greater is the amplitude of vibration of the membrane and hammer, and consequently the more powerful the blow upon the anvil, and the vibration of the nerves by means of the fluid.

The office of our organs of hearing is, therefore, to transmit with certainty up to the auditory nerve every condensation and rarefaction occurring in the surrounding medium. But the office of the auditory nerve is to bring to our consciousness the vibrations of matter which have occurred in a given time, both as regards number and amplitude. Here, for the first time, certain combinations receive a name; here, certain vibrations are *tones* or *noises* [*Töne* oder *Misstöne*].

What our auditory nerve perceives is, then, simply the effect of a force coming within the range of consciousness, and this force can be represented both as to duration and magnitude graphically by a curve.

Let *a b* represent any given time, and the curve above the line condensation (+), the curve below the line rarefaction (—), then any ordinate raised from the end of any abscissa will represent the degree of condensation, at the time represented by its base, in consequence of which the drum of the ear vibrates.

Our ear can under no circumstances appreciate more than can be represented by these curves, and this indeed is entirely sufficient to give us a clear perception of any tone [Ton] or any combination of tones.

If several tones [Töne] are produced at the same time, the conducting medium is subjected to the influence of several simultaneous forces, and the two following laws will hold good: If the forces act all in the same direction, the amplitude is proportional to the sum of the forces; if the forces act in opposite directions, the amplitudes are proportional to the difference of the opposing forces.

If, for example, in the case of three tones, we draw the curve of condensation of each separately, then by a summation of the ordinates of corresponding abscissas, we can determine new ordinates and develop a new curve, which might be called the combination curve. This represents exactly what our ear perceives of the three simultaneous tones. The fact that the musician can distinguish the three tones need not surprise us any more than the fact that any one acquainted with the theory of colors can in green discover blue and yellow; but the combination curves in Plate I. show that this difficulty is a slight one, for in these curves all the relations of the components successively recur. In the case of chords of more than three notes, the relations are not so readily seen from the drawing, Plate II., for example. In the case of such chords, however, the skilled musician also finds difficulty in recognizing the separate notes.

Plate III. illustrates discord [Dissonanz]. Why discords impress us unpleasantly I will leave my readers to judge at this time, though I may perhaps return to the subject subsequently in another paper.

From the preceding it follows: —

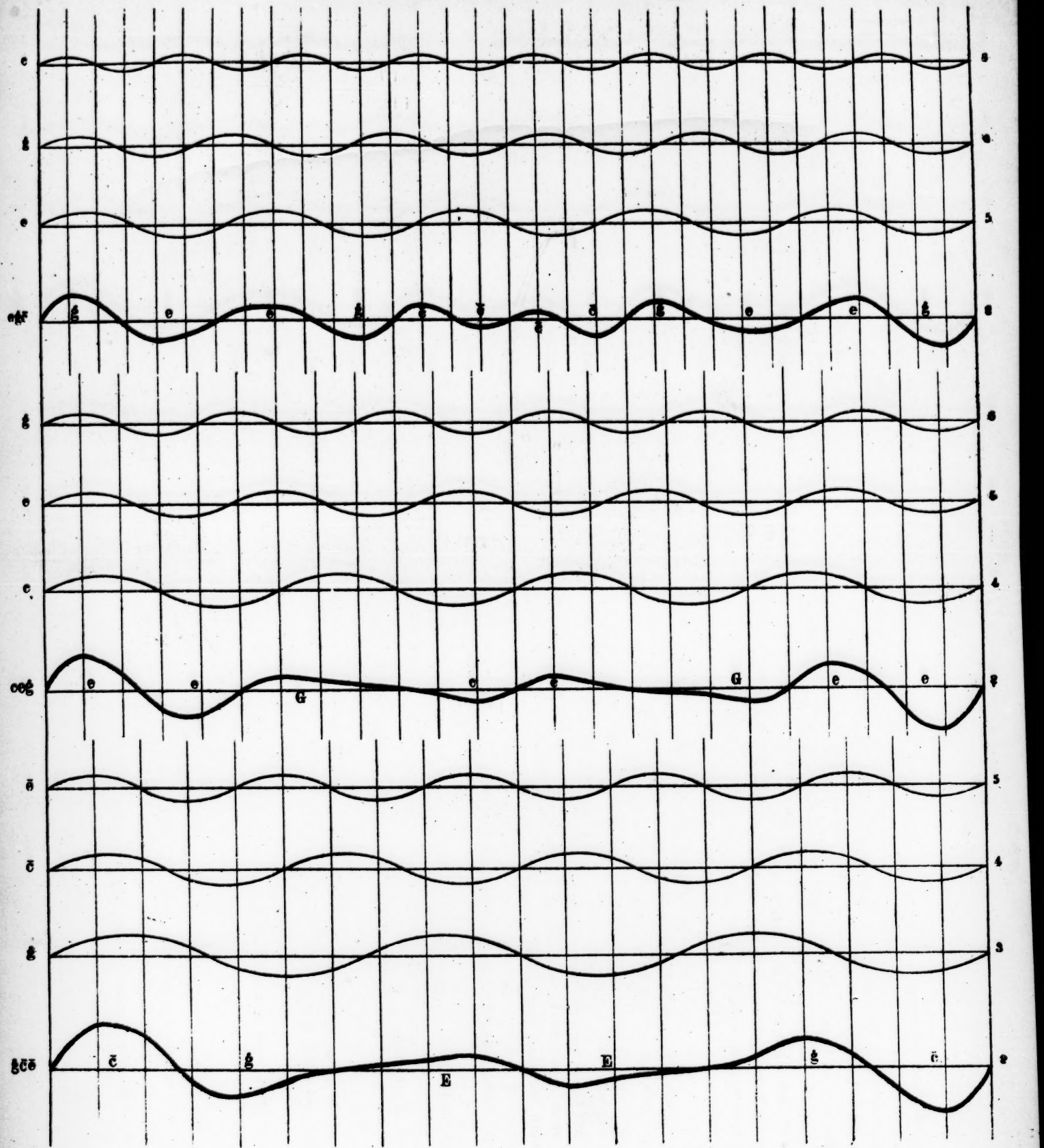
First. Every tone [Ton] and every combination of tones, on striking our ear, causes vibrations of the drum of the ear, the succession of which may be represented by a curve.

Second. The succession of these vibrations alone gives us a conception (sensation) of the tone, and every alteration changes the conception (sensation).

As soon, then, as it is possible to produce, anywhere and in any manner, vibrations whose curves shall be the same as those of any given tone or combination of tones, we shall receive the same impression as that tone or combination of tones would have produced on us.

1867

Umkehrungen eines Dreiklanges. Tafel I.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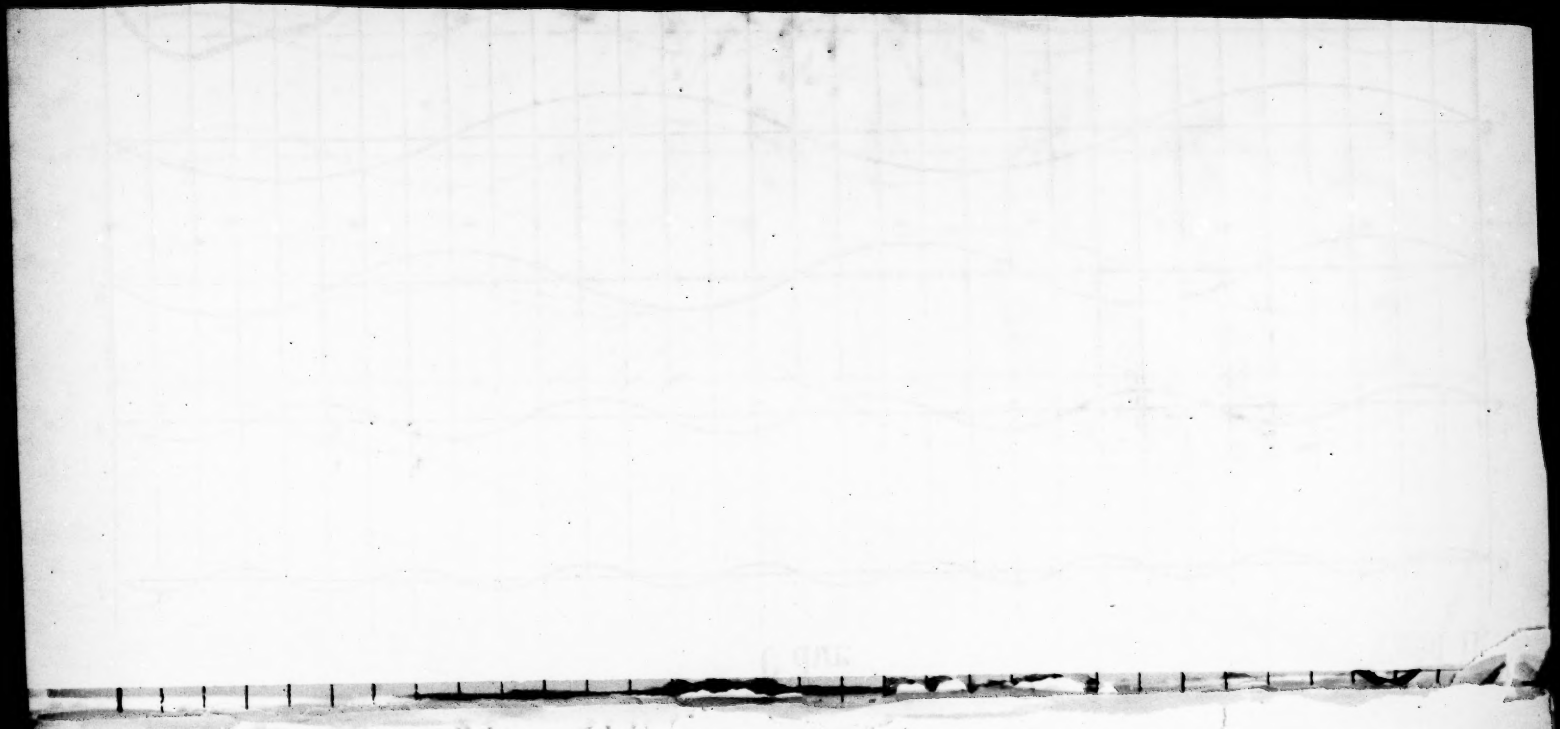

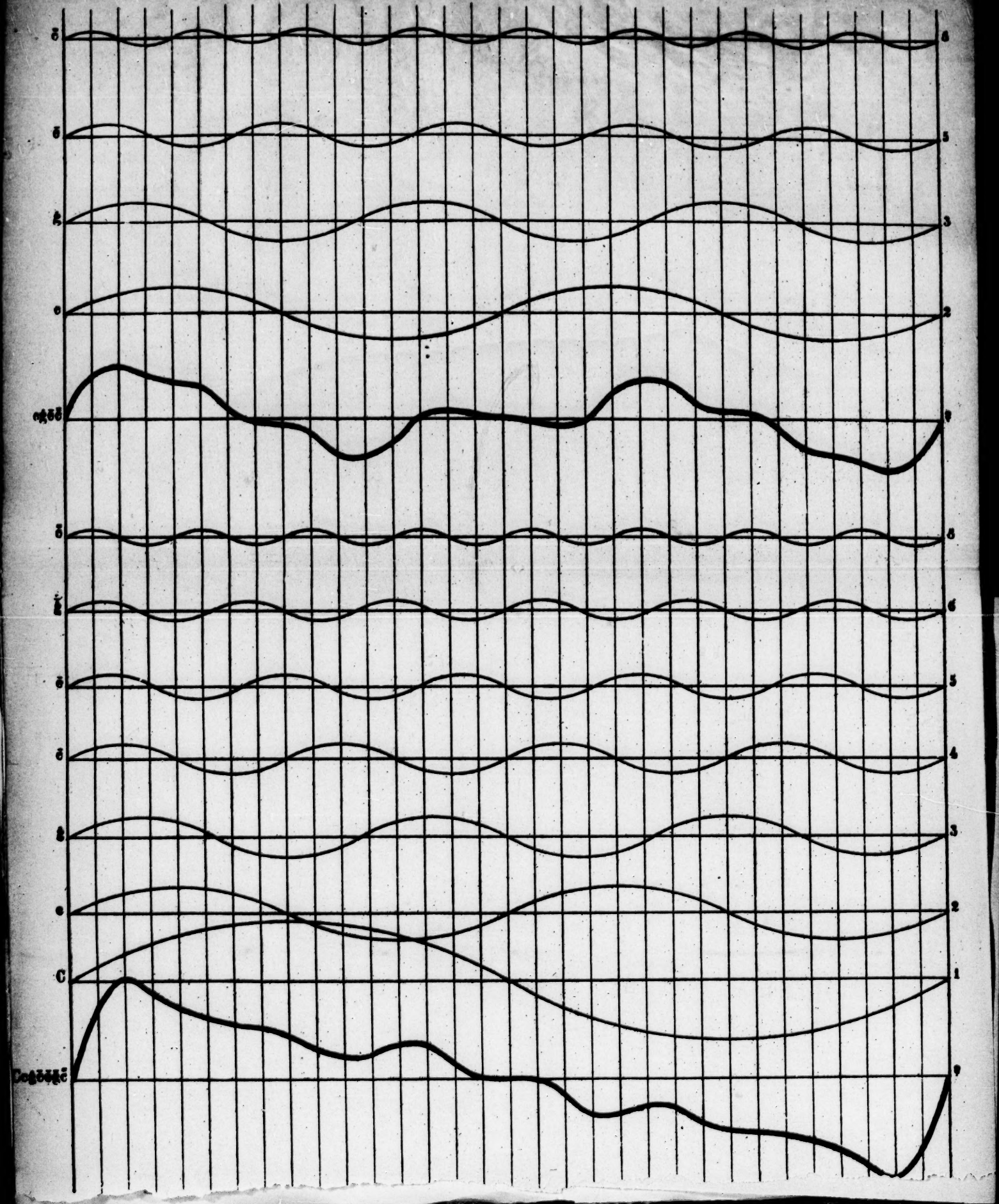
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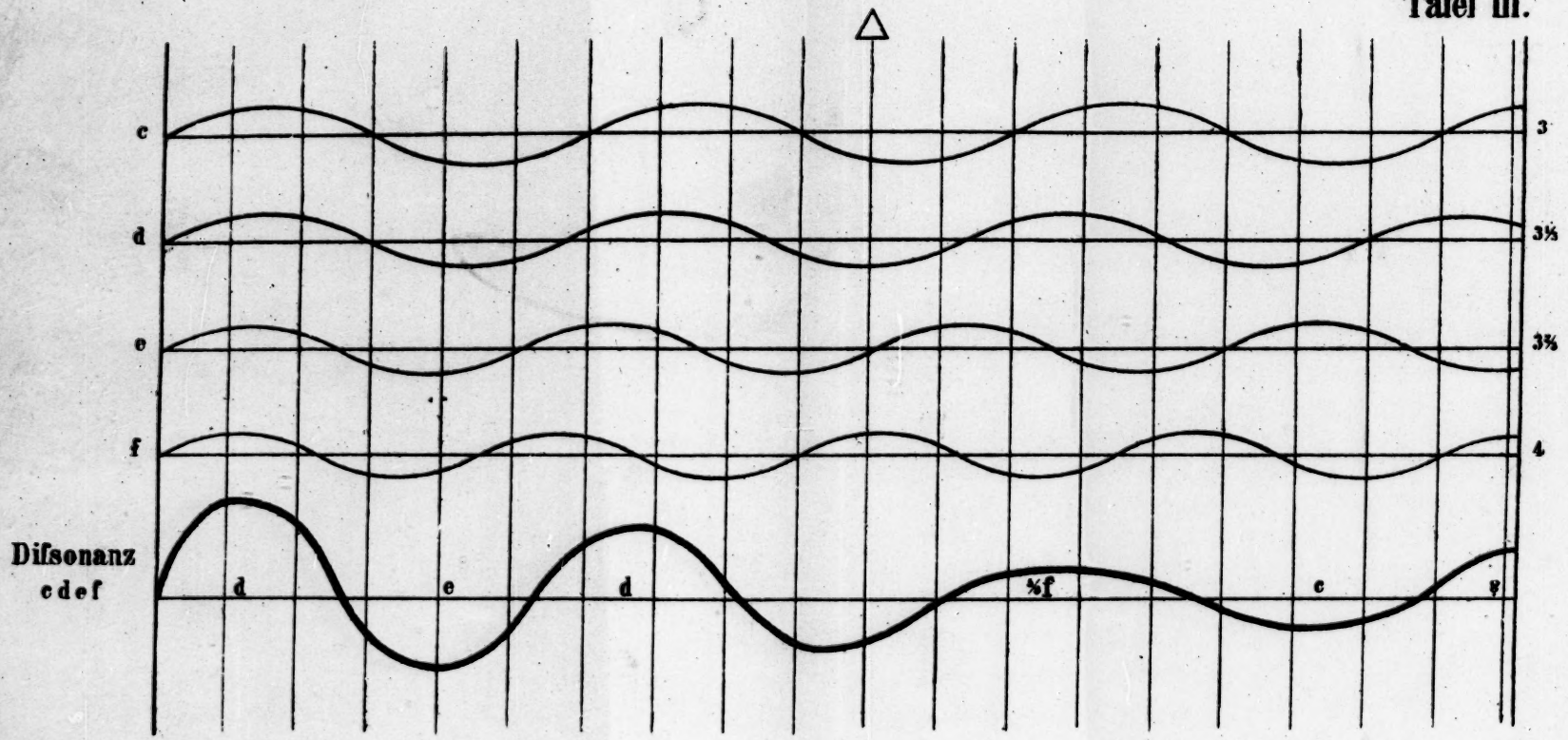
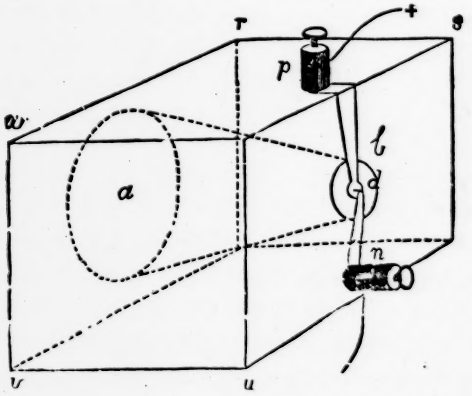
Tafel III.



With the above principles as a foundation, I have succeeded in constructing an apparatus with which I am enabled to reproduce the tones of various instruments, and even to a certain extent the human voice. It is very simple, and by means of the figure will be easily understood from the following explanation: —



In the cubical block of wood *r s t u v w x* there is a conical perforation *a*, closed at one end by a membrane *b* (pig's intestine), upon the middle of which there is cemented a conducting strip of platinum; this is connected with the binding screw *p* [auf deren Mitte ein stromleitendes Streifchen Platin festgekittet ist. Dieses steht mit der Klemme *p* in Verbindung]. From the binding screw *n*, another thin strip of metal [ein dünnes Metallstreifchen] extends until over the middle of the membrane, and ends here in a platinum wire placed at right angles to its length and surface.

From the binding screw *p*, a conducting wire runs through the battery to distant station, being connected with a coil of silk-covered copper wire and this again is connected with a conductor leading back to the binding screw *n*.

The coil at the distant station is about six inches long, is composed of six layers of fine wire, and, as a core in its centre, has a knitting-needle which projects about two inches at both ends. By means of the projecting ends, the coil rests upon two bridges of a resonant case. (All this part can, of course, be replaced by

any other apparatus by means of which the well-known "galvanic tones" can be produced.)

If now tones or combinations of tones are produced in the neighborhood of the block, so that sufficiently powerful waves enter the opening *a*, then these sounds cause the membrane *b* to vibrate. At the first condensation the hammer-like wire *d* is pushed back; at the rarefaction it cannot follow the retreating membrane, and the current traversing the strips remains broken [Strom bleibt so lange unterbrochen bis, *etc.*], until the membrane forced by a new condensation again presses the strip (proceeding from *p*) against *d*. In this way each sound wave causes a breaking and closing [ein Oeffnen und ein Schliessen] of the current [Stromes].

At each closing [Schliessen] of the circuit [Kette], the atoms of the iron wire inside the distant spiral are moved away from each other (Pouillet Müller, p. 304, Vol. II., fifth edition); on breaking the circuit [beim Unterbrechen des Stromes], these atoms seek to regain their position of equilibrium. When this happens, in consequence of the reciprocal actions of elasticity and inertia, a number of vibrations are produced, and they give the longitudinal sound of the rod (see as above). This is the case if the making and breaking of the current [Unterbrechungen und Schliessungen des Stromes] occur with comparative slowness. If they occur more rapidly than the oscillations of the iron core, due to its elasticity, the atoms cannot complete their course. The paths described become shorter in proportion as the interruptions are more frequent, but then are just as numerous as these.

The iron wire no longer gives its longitudinal normal tone, but a tone whose pitch corresponds to the number of interruptions [Unterbrechungen] (in a given time); this is the same as saying that *the rod reproduces the tone* [Ton] *impressed upon the interrupter* [dem Unterbrechungsapparat]. The intensity also of this tone is proportional to that of the original one, for in proportion as this is more intense, the motions of the membrane are greater; the motions of the hammer, also, and finally the time during which the circuit remains opened, is greater; and consequently, up to a certain limit, the motions of the atoms in the reproducing wire are greater, we perceiving them

as greater vibrations, in just the same way as we would have perceived the original sound wave.

As the length of the conducting wire can undoubtedly be made as great as in direct telegraphy, I have called my instrument "telephone."

Now, in reference to the capabilities of the telephone, it may be stated that I was enabled to render audible to the members of a large assembly (The Physical Society at Frankfort-a-M.) melodies which were sung (not very loud) into the apparatus in another house (three hundred feet away) with closed doors.

Other experiments showed that the sounding wire was capable of reproducing complete chords of three tones of a piano, upon which the telephone was placed, and that it reproduces equally well the tones of other instruments, accordion, clarinet, horn, organ pipes, etc., provided that the tones are within the compass F — $\bar{\bar{f}}$.

Of course, in all experiments, sufficient precautions were taken to insure that there was no direct conduction of sound. This is very easily done by making a momentary short circuit immediately in front of the coil, by which means its action is temporarily interrupted.

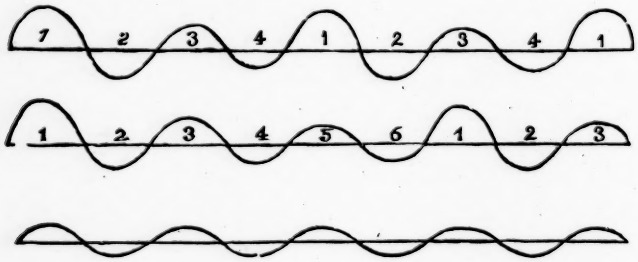
Hitherto it has not been possible to reproduce the tones of human speech [Tonsprache des Menschen] with a distinctness sufficient for every one. The consonants are for the most part reproduced pretty distinctly, but the vowels as yet not in an equal degree. The cause of this I will attempt to explain.

According to the experiments of Willis, Helmholtz and others, vowel tones can be produced artificially, if the vibrations of one body are from time to time augmented by those of another, somewhat as follows: —

An elastic spring is set in vibration by the blow of a tooth on a toothed wheel; the first vibration is the greatest, and each subsequent one is smaller than the preceding.

If, after a few vibrations of this kind (the spring not coming to rest in the mean time), the tooth wheel imparts a new stroke, the following vibration will be again a maximum, and so on.

The pitch of the tone produced in this way depends upon the number of vibrations in a given time, but the character of the tone upon the number of swellings [Anschwellungen] in the same time. Two vowels having the same pitch would differ in about the way represented by the curves (Figs. 1, 2), while the same tone without any vowel character would be represented by the curve (Fig. 3).



Our organs of speech probably produce the vowels in the same manner, through the combined action of the upper and lower vocal cords, or of these latter and the cavity of the mouth.

My apparatus reproduces the number of vibrations, but with an intensity much less than that of the original ones; though, as I have reason to believe, to a certain degree proportional among themselves. But in the case of these generally small vibrations, the difference between large and small vibrations is more difficult to perceive than in the case of the original waves, and the vowel is therefore more or less indistinct.

Whether or not my views as to the curves corresponding to sound combinations are correct could perhaps be decided by means of the new phonautograph of Duhamel ("Vierordt Physiology," page 254).

It may be that for the practical application of the telephone much remains to be done; for physics it has already sufficient interest, from the fact that it opens a new field for research.

Friedrichsdorf, near Frankfort-a-M., December, 1861.

1874

No. 8. — JAHRESBERICHT DES PHYSIKALISCHEN VEREINS ZU FRANKFURT AM MAIN, für das Rechnungs Jahr 1861–1862.

[*Extract from the "Proceedings."*]

Page 13. October 26, 1861. "By Mr. Ph. Reis, of Friederichsdorf. On the Transmission of Musical Tones to desired distances by means of the galvanic current."

November 16, by the same: "Statement of a new theory about the perception of chords and the quality of sounds [*Klang farben*], as a continuation of and supplement to the lecture on the telephone."

No. 9. — DIE FORTSCHRITTE DER PHYSIK, Dargestellt von der physikalischen Gesellschaft zu Berlin, XVII., im J., 1861, pp. 171–173.

[Progress in the Natural Sciences. Published by the Physical Society of Berlin. 1861, Vol. XVII., pp. 171-173.]

PH. REIS. *Telephony by means of the electric current.* (*Annual Report of the Physical Society of Frankfort on the Main*, 1860–1, *pp.* 57–64.)

By the name "Telephone" the author designates the following apparatus of his own construction, by means of which and with the help of the galvanic current he is enabled "to reproduce at a distance the tones [Tönen] of different instruments and even to a certain degree the human voice."

A wooden cube is bored through from one of the faces to the opposite one, the cavity taking the shape of a cone; the smaller opening is closed by means of a membrane [hog's intestine, Schweinsdünndarm]. On the middle of the membrane and parallel with it is a thin strip of platinum cemented fast at one end whilst the other end is held by a binding post [Klemme] *p*. From another binding post *q* extends a similar thin strip of metal as far as over the centre of the membrane, and carries a little platinum wire directed towards the membrane at right angles to the strip and the surface of the membrane. From binding post *p* a conductor leads through a battery to a distant coil, which again is connected by another wire to binding post *q*.

The coil at the distant station is about six inches long, consists of

1875

six layers of thin wire and encloses as a core a knitting needle which protrudes about two inches at each end. By these protruding ends the coil is supported on two bridges of a sound board. If now tones or combinations of tones are produced in the vicinity of the large opening of the conical cavity so that sufficiently strong waves enter it, these waves will set the membrane into vibration; by the outward motion of the membrane the platinum strip cemented on it is pressed against the hammer-shaped wire *d* and the galvanic current [Strom] is closed [geschlossen]; by the inward motion of the membrane the current is reopened. The alternate magnetizings and demagnetizings of the core of the coil resulting therefrom will bring forth, if the alternation is slow, the longitudinal tone of the core, and if the alternation [aufeinanderfolge] is quicker, a longitudinal vibration of the same, the period of which corresponds to the period of the interruptions of the current [Unterbrechungen des Stromes] or of the vibrations of the membrane, and consequently to the rate or pitch of the tone which entered the conical cavity. That means according to the author that "The rod [Stab] reproduces the tone which was impressed upon the interrupting apparatus [Unterbrechungsapparat]." "The strength of this tone is also proportionate to the original tone, for," as the author, though not very accurately, explains, "the stronger this is, the greater the motion of the little hammer, the greater finally the time during which the circuit remains open, and consequently the greater, up to a certain limit, the motion of the atoms in the reproducing rod, which motions affect us as greater vibrations, as the original wave itself would have done." By means of this telephone the author made audible to the members of a large meeting of the Physical Society in Frankfort-a-M. melodies sung not very loud into the apparatus, in a house situated about three hundred feet distant, with closed doors. "Other trials showed that the resounding rod is capable of reproducing full chords [Dreiklänge] of a piano on which the telephone rests, and that, in short, it reproduces just as well the tones of other instruments, such as the harmonica, clarinet, horn, organ pipe, etc., provided the tones are within a certain range, from F to f^2 or thereabout.

"As a matter of course, sufficient care was taken to ascertain whether direct transmission of the sounds had not a share in the

1876

result. This was ascertained very simply by establishing for a given time a good shunt circuit directly before the coil, in consequence of which, of course, the activity of the latter ceased for that time.

"It was not possible thus far to reproduce spoken tones [Tonsprache des Menschen] with a distinctness satisfactory to all; the consonants are for the most part distinctly reproduced, the vowels not in the same degree." The author attempts to explain this imperfect reproduction of the vowels by saying that the apparatus reproduces the vibrations to a certain extent indeed with proportionate, but also reduced strength, and the ear can no longer satisfactorily discern the relation of the proportionately great vibrations which determine the pitch [Tonhöhe] to the small vibrations on which vocal quality [vocal Farbe] depends.

No. 10. — AUS DER NATUR, DIE NEUESTEN ENTDECKUNGEN AUF DEM GEBIETE DER NATURWISSENSCHAFTEN,* Leipzig, 1862, Vol. XXI., pp. 470–74.

[Nature, the latest discoveries in the realm of the Physical Sciences.]

TELEPHONY.

The immense velocity of transmission possessed by electricity directed attention, as long ago as the middle of the last century, as to the possibility of using this unknown force for sending messages with rapidity to a great distance; but not until within twenty years has telegraphy, by means of the galvanic current, come into practical use, and has now so far advanced that the telegraphic apparatus animated by the galvanic current commits the messages to paper. These surprising successes in the field of telegraphy have probably often pushed into the foreground the question of the possibility of the direct transmission of speech. Experiments in that direction, however, had not as yet shown any satisfactory results, because the vibrations of sound quickly lose their intensity through the media of transmission, to such an extent that they become indistinguishable to our senses.

* This article is a paraphrase of Reis's Lectures (No. 7, p. 11, *supra*), but has not plates I., II. and III. This article and No. 7 were translated from the German by different persons.

Probably some have thought of a reproduction of sounds by means of the galvanic current, but the very persons who would have been the most capable, on account of their knowledge and resources, hesitated to undertake the solution of the problem, and were most sceptical as to its practicability. To those less acquainted with physics, the problem when they understand it appears less difficult because they do not foresee the difficulties. So had Reis at Fredrichsfeld, at Frankfurt-a-M., about nine years ago, — as he himself says, with much enthusiasm for the novelty, and with limited knowledge of physics, — the audacity to attempt a solution of this problem, but was soon obliged to abandon it because the first experiment convinced him of its impossibility. Later on, after further study, Reis could see that his first experiment was very crude and in nowise convincing. But he did not then take up the question again in earnest, because he considered himself unequal to the task of overcoming the obstacles to be encountered on the way. But the impressions of youth are strong and not easily obliterated, and consequently Reis could not banish the impression produced by his first experiment; and in spite of the opposition of his judgment, and half against his will, the project of his youth was taken up again at many a leisure hour, and the obstacles and the means of overcoming them balanced, but not as yet put to the test of experiment.

How should one instrument reproduce the combined movements of all the organs brought into activity by human speech? This was always the cardinal question. At last Reis was struck with the idea of putting this question in a different form, as: How does our ear perceive the total vibrations of all the organs of speech in activity at the same time? Or taken more generally, how do we perceive the vibrations of various bodies sounding at the same time? To answer this question, let us see what must be done in the first instance to perceive each separate sound.

Without an ear each separate sound is nothing but the quick repeating (at least 7–8 times a second) of rarefactions and condensations of a body. If this happens in the same medium in which we ourselves are contained, the membrane of our ear will be forced into the cavity of the ear with each condensation, and

by the following rarefaction will move in the opposite direction. These vibrations cause the hammer to be lifted from and dropped upon the anvil in the same measure of time, or according to others, an approach and recession of the minute bone atoms of the ear and a corresponding number of vibrations of the cochlea substance or fluid in which the ends of the nerve of hearing are spread. The greater the condensation of the sound-conducting medium at a given moment, and the longer the vibrating width of the membrane and the hammer, the stronger, consequently, will be the stroke on the anvil and the vibration transmitted through the fluid to the nerves.

According to this, it is the office of the organs of hearing to carry every condensation or rarefaction which occurs in their surrounding medium with accuracy to the nerve of hearing; and the office of the nerve of hearing is to bring the vibrations of matter in a given time as well by number as by size to our consciousness. Not until now do certain combinations receive definite names. Not until now do certain vibrations become melodies or discords.

Whatever comes to the sensibility of the nerve of hearing is therefore merely the activity of a power brought to our consciousness, and this may be graphically illustrated by a curve according to time and size, as in Fig 1.

FIG. 1.

The line *a-b* is to indicate any given time, and the curve above the line (+) condensation, and the curve under the line (—) rare faction; so each ordinate erected at the end of an abscissa shows us the strength of condensation at a given moment at the starting point, in consequence of which the membrane vibrates. Anything other than can be illustrated by similar curves, our ear is absolutely unable to perceive, and this is sufficient to bring every source and combination of sound clearly to our consciousness.

When various sounds are created at the same time, the sound-conducting medium is under the influence of various simultaneous forces, and the following two laws are imperative: If all the forces act in the same direction, the size of the wave is proportional to the

total of the forces; but if the forces act in opposite directions, the size of the wave is proportional to the difference of the opposed forces.

If, for instance, we illustrate singly the condensation curves of three sounds, we can, by summing the ordinates of equal abscissæ, designate new ordinates and establish a new curve, which we may call a combination curve, and this will show us precisely what our ear perceives at the same time of the three combined sounds.

That a musician would recognize again each separate sound is not to be wondered at, more than the fact that one acquainted with the science of colors should readily discern in green the colors of blue and yellow. The combination curves show these differences in a very limited degree, as in them reappear successively all the proportions of the components. In accords of more than three sounds it is certainly not so easy to recognize the proportions in the drawing, but it is equally difficult for a good musician to distinguish in such accords each separate sound.

From the above we can see that as soon as it shall be possible to create vibrations anywhere and in any manner whose curves are equal to those of a certain sound or combination of sounds, we shall receive the same impression as the sound or combination of sounds would have produced. Placing himself upon these principles, Mr. Reis succeeded in constructing a very simple apparatus, as shown in Fig. 2, by the aid of which he is enabled to reproduce the sounds of various instruments, and to a certain degree also the human voice.

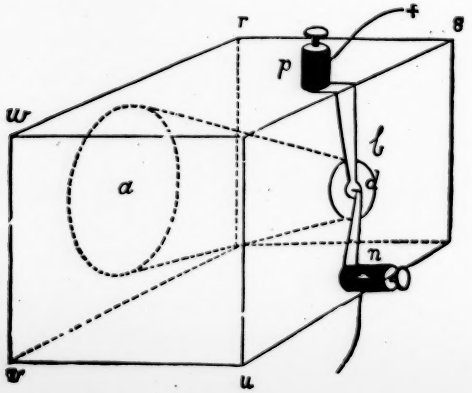


FIG. 2.

On the wooden cube (r, s, t, u, v, w, x) is the cavity (a), closed on one side by the membrane (b) of hog's intestine, on the centre of which is fastened a platina strip, which serves as conductor to the galvanic current. This is connected with the binding screw (p). From the binding screw (n) another small metallic strip is placed over the centre of the membrane, and is connected with a platinum wire, which is placed at a right angle with the longitudinal axis and the broad side of the cube. From the binding screw (p) a conducting wire goes through the battery to a distant station, and ends there in a spiral of silk-covered copper wire, which again leads back to the conductor which ends in the binding screw (n).

The spiral at the distant station is fully six inches in length, and carries six layers of thin wire, and has in its centre as a nucleus a knitting needle which protrudes on each end fully two inches. The spiral rests with the protruding ends of the wire on two bridges of a sounding board. Of course the whole of this part can be replaced by any apparatus by which you can produce the well-known galvanic tones.

If now sounds, or combination of sounds, are produced in the vicinity of this block so that strong waves will enter the opening (a), they will cause a vibration of the membrane (b). With the first condensation the hammer-shaped wire (d) will be pushed back; with the following rarefaction the wire cannot follow the retreating membrane, and the current which flows through the strip remains interrupted until the membrane is driven back by a new condensation and presses the strip again from (p) to (d). Every wave of sound thus produces an opening and closing of the current.

Every closing of the circuit causes the atoms of the needle at the distant station to repel each other and to seek again their natural position at every interruption of the current. As this occurs, they make, in consequence of the alternate action of elasticity and inertia, a number of vibrations, and give the longitudinal sound of the wire. Such is the action when the opening and closing of the current is comparatively slow. If they occur faster than the oscillations of the iron rod which are dependent upon elasticity are produced, the atoms cannot describe their full course. Their courses grow shorter as the interruptions grow faster, but still are just as frequent as these [dafür aber ebenso häufig, als diese]. The iron rod no longer gives

its longitudinal sound, but a sound whose pitch agrees with the number of interruptions in a given time.

All this means that the rod produces the sound that is transmitted to it through the interrupting apparatus. The strength of the sound also is in proportion to the original source, for the stronger the original sound, the stronger the vibration of the membrane, and the greater the movement of the minute hammer the longer the time that the circuit remains closed; and consequently the larger to a certain degree the movement of the atoms in the reproducing rod, which we perceive as a longer vibration, just as we should have perceived the original wave.

As to the length of the conducting wire, it can be stretched as far as in telegraphy by the galvanic current. Reis has given this apparatus the name of "Telephone." In regard to what it is able to accomplish, it may be mentioned that Reis has been able, before a largely attended meeting of the Physical Society at Frankfurt-a-M., to produce audible melodies which were sung not very loudly into an apparatus placed in the closed room of a house three hundred feet distant. Other experiments have proved that the rod is able to reproduce triple sounds of a piano on which the telephone stands; and, finally, that the same will reproduce the sounds of other instruments, such as the concertina, clarinet, horn, organ pipes, etc., provided the sounds belong to a certain range, say F to $\bar{\bar{f}}$. It is needless to mention that at all these experiments there was sufficient investigation to prevent a direct conduction of sound. This investigation can easily be made by a good interrupter placed close to the coil, which of course stops the operation of the instrument for the time being.

Up to this time it has been impossible to reproduce the sound of human speech in such a degree as to be perfectly audible to any one. The consonants were in most cases reproduced almost perfectly, but not so the vowels; the cause of this may be found in the following.

As has been ascertained by the experiments of Willis, Helmholz and others, vocal sounds can be artificially produced by increasing the vibrations of a body at intervals through another body, as, for instance, an elastic spring is set in vibration by the stroke of the cog of a wheel; the first vibration is the largest, and every following one is smaller than its predecessor.

FIG. 3.

If after a few vibrations of this kind another stroke follows before the spring comes to a rest, the next vibration will again be the largest and so on.

The height and depth of a sound depends upon the number of vibrations made in a given time, and the character of the sound upon the number of such cog strokes in a given time. Two vowels at the same pitch may be illustrated and distinguished in Figs. 4 and 5, whereas the same sound without the attributes of a vowel may be illustrated by Fig. 6.

FIG. 4.

FIG. 5.

FIG 6.

Our organs of speech probably produce the vowels in the same way through a combined action of the upper and the lower glottis, or the latter and the cavity of the mouth. The apparatus gives us the number of vibrations, but their force is much reduced from the original, and most likely, to a certain degree, proportionally among them all. This difference between the generally smaller vibrations is certainly much harder to recognize than the original wave, and therefore the vowels are more indefinite.

There certainly remains much to be done towards a practical development of telephony; but as the beginning has now been made, we shall not have long to wait for further advance. A broad field of labor has thus been opened for the physicist.

No. 11. — DIDASKALIA, Frankfort-a-M., May 8, 1862.

[For full title of this publication, see No. 2, p. 4.]

The excellent physicist, Mr. Phil. Reis, of Friedrichsdorf, calls by this name his surprising invention for using the telegraph line to transmit really audible tones. Our readers will perhaps remember having heard, some time since, of this invention, the first trials with which Mr. Reis performed here in the Physical Society. Since

then the invention has been constantly developed, and will, no doubt, become of great importance.

(Didaskalia), May 12, 1862.

Yesterday's meeting of the Free German Institute was a very numerously attended one, from the fact that the subject in the order of business, "Telephony by Transmission of the Galvanic Current," as explained by the inventor himself, Mr. Phil. Reis, excites so great an interest that it rightly deserves the most general attention.

In a lecture exceedingly interesting, universally understood, clear and concise, Mr. Reis gave a historical outline of the origin and development of his idea of the practical possibility of the transmission of tones in a galvanic way.

His first attempts were mostly unsuccessful in solving the cardinal question propounded by him, "How is it possible that a single instrument can reproduce at once the total action of all the organs operated in human speech?" until finally it occurred to him to seek the solution of the problem in the question, "How does our ear take cognizance of the total vibrations of all the organs of speech acting at once?" or "How do we perceive the vibrations of several bodies sounding at once?"

In order to answer this question, the lecturer went more closely into the anatomy of the ear, and into the formation of tones in general. After this was determined, he took up again his experiments in reference to the transmission of tones by means of galvanism.

Afterwards Mr. Reis constructed, considerably enlarged, the parts of the ear necessary for hearing, by which it was finally possible for him to transmit the tones brought to the mechanically imitated ear.

The experiments by him some months ago, in the Physical Society, were, to the astonishment of all, exceedingly plain and clear, whereas the experiment following the lecture of yesterday was less successful. This was due partly to the poor conductivity of the wires, partly to the locality.

Although much is left to be done for the practical utilization (Verwerthung) of the telephone, yet a new and interesting field of labor is hereby opened to physics.

[The above translations are those published in *Philipp Reis: Inventor of the Telephone.* By Silvanus P. Thompson, B. A., etc. London: E. & F. N. Spon. 1883.]

1884

No. 12. — ZEITSCHRIFT DES DEUTSCH-OESTERREICHISCHEN TELEGRAPHEN VEREINS, Berlin, 1862, Vol. IX., p. 125.

[Journal of the German-Austrian Telegraph Association, Vol. IX., p. 125, 1862.]

Concerning the reproduction of sounds by means of galvanic electricity: by V. Legat, Royal Prussian Telegraph Inspector at Cassel, accompanied by copperplates VIII. and IX.

It might not be uninteresting to make known, in wider circles, the following ideas lately communicated by Mr. Philip Reis to the Society of Physics, and to the meetings of the Free German Institute, at Frankfort on the Main, concerning the reproduction of tones [Tönen] by means of galvanic electricity, and also what has been hitherto accomplished towards the realization of this project, in order that the accumulated experiments may serve as a foundation to build upon, and that the capacity of the electric current, which by human ingenuity has already been made serviceable for correspondence, may be developed in this direction also.

In this essay we shall not deal with the electric current as to its capacity for operating telegraphic apparatus of whatever construction for the reproduction of *visible* signs, but of the application of this current to the production of *audible* signals, of *tones* [Tönen].

The air waves, which by acting upon the ear excite in us the sensation of sound by primarily setting the tympanum of the ear into vibratory motion, are, as is well known, transmitted to the interior parts of the ear and to the auditory nerves there located by means of a lever apparatus of wonderful delicacy, the auditory bones (hammer, anvil, stirrup); and the attempt to reproduce tones therefore depends upon this, to actuate an artificial imitation of this lever apparatus by means of the vibrations of a membrane corresponding to the membrane of the ear drum, and thereby to open and close (zum Oeffnen ũ Schliessen) a galvanic circuit, connected with a distant station by a metallic conductor.

Before describing the apparatus to be used, it would be proper to inquire how our ear apprehends the vibrations of any one particular tone, and the combined vibrations of all simultaneous tones acting upon it, because thereby we may determine the operations which are

1885

to be performed by the transmitting and receiving apparatus in the solution of the problem.

Examining first the processes which take place in order that the human ear may apprehend any single tone, we find that each tone is the result of alternate rarefactions and condensations repeated within a fixed time. If this operation occurs in the same medium in which the ear is placed, then at each condensation the membrane is forced toward the cavity of the drum and toward the opposite side at each rarefaction.

These vibrations cause corresponding movements in the auditory bones, and are thereby transmitted to the auditory nerves.

The greater the degree of condensation of the sound-conducting medium is at a given time, the greater will be the amplitude of vibration of the membrane and auditory bones, and the greater the consequent result; and in the opposite case, so much the weaker. Hence it is evidently the function of the auditory apparatus to impart with faithfulness to the auditory nerves every condensation and rarefaction which occurs in the surrounding medium. On the other hand, the function of transmitting to our consciousness both the number and amplitude of the resulting vibrations occurring within a given time devolves upon the auditory nerves.

It is here, in our consciousness, that a certain complex phenomenon receives a specific name; it is here, in our consciousness, that the transmitted vibrations become tones [Tōne].

Accordingly, that which is apprehended by the auditory nerves is the effect of a force, reaching to our consciousness, and which can be made more easy of comprehension as to duration and strength, by graphical delineation.

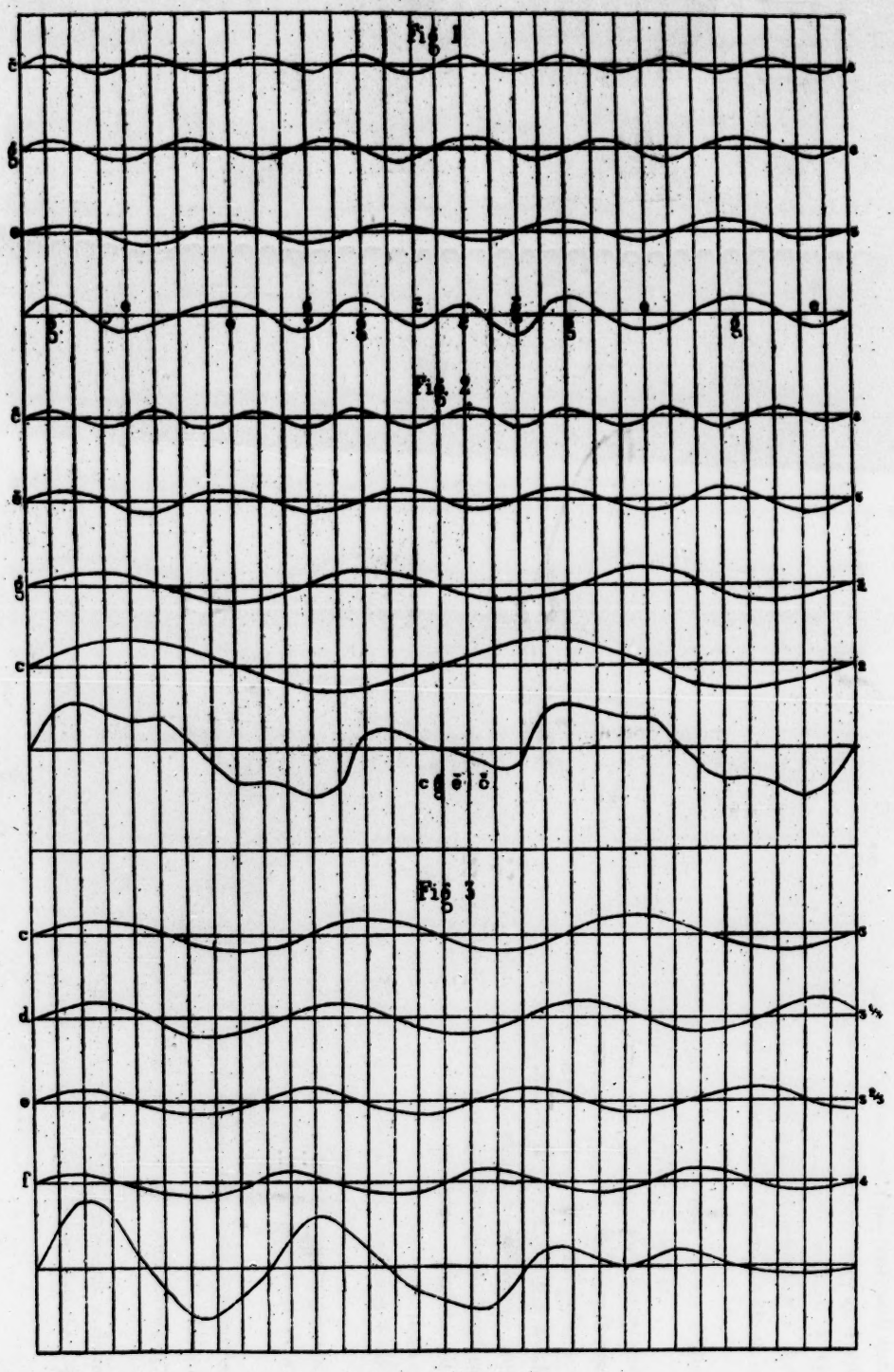
For example, let the length of the line *a–b* represent a definite period of time, the curves above this line the condensations (+),

and the curves below this line the rarefactions (—); then every ordinate erected at the end of any abscissa will indicate at the moment of time indicated by this abscissa the degree of condensation in consequence of which the membrane of the drum vibrates.

The ear is not capable of perceiving more than can be represented

1886

Legat Reproduction von Tönen auf elektro galvanischem Wege.



Ernst & Korn Berlin.

in this way, or more than can be represented by similar curves; this is, however, sufficient to convey to our consciousnes any single tone [Ton] or any desired combinations of tones. For if several tones are generated simultaneously, then the sound-conducting medium is influenced by several forces, acting at the same time, and subject to mechanical laws.

If all the forces act in the same direction, then the amount of motion is in proportion to the sum of all the forces; if on the other hand the forces act in opposing directions, then the amount of motion is in proportion to the difference between the opposing forces.

From these principles it follows that the curves representing the condensations of a number of simultaneously generated tones may be combined in a single curve of condensation, which will indicate with precision what our ear apprehends through the reception of these simultaneously acting tones.

The objection generally made to this proposition, that a musician, or any person, is able to distinguish the simple tones out of which these composite curves are formed or arise, should not be allowed to militate against it; as it is also possible for some who are familiar with the study of colors to distinguish, in green, for example, the mixture of yellow and blue, in their varied shades; and the one phenomenon as well as the other is referable to the fact that in both cases the observer is familiar with the factors of that product which has been conveyed to his consciousness.

By the explanations heretofore given, it is easy to construct the curves representing the condensations of various tones, chords, etc., and a few examples are given by way of illustration: —

Fig. 1, Plate VIII., represents a composite curve formed of three tones, in which all the proportions of the components recur successively.

Fig. 2 represents a similar curve formed of more than three tones; in this case, however, it is no longer possible to represent the proportions so clearly in the drawing, yet an experienced musician will be able to discern them even here, although in practice it might be difficult even for him to recognize the separate tones in such a chord.

The advantage of representing the operation of tones upon the human ear after this manner is that it gives the clearest view possible of the process; the representation here given also shows why a discord [Dissonanz], Fig. 3, must affect the ear disagreeably.

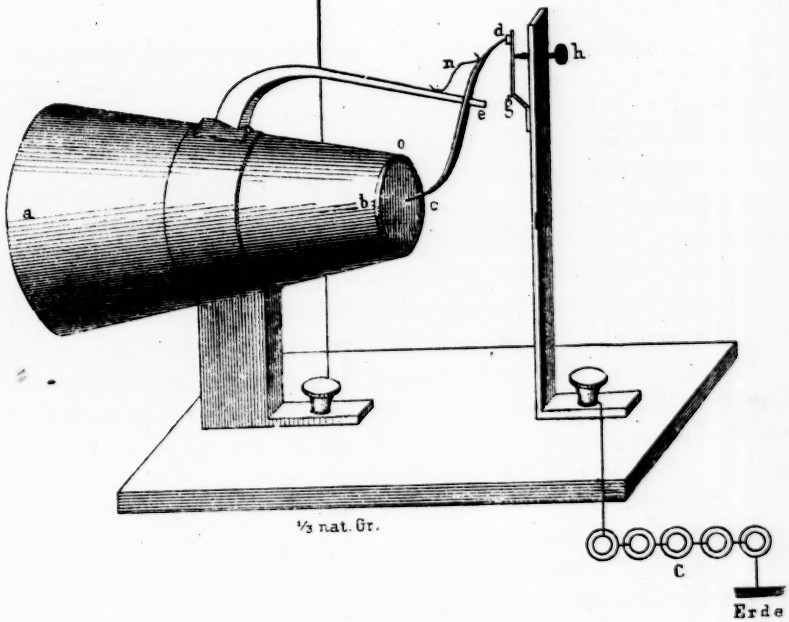
This apparent digression from the subject under consideration was necessary to demonstrate that as soon as we are able, in any place and in any manner, to reproduce vibrations, of such curves and intensities as are equivalent to the curves and intensities of the vibrations of any particular tone, or of any particular combination of tones, we shall have the same impressions as were produced upon us by this original tone, or these original combinations of tones.

The apparatus described hereafter offers the possibility of producing these vibrations in every manner desired; and by the use of galvanic electricity it is possible to evoke, at any distance, vibrations like [gleiche] those which have been so produced, and in this way to reproduce at any place the tones which have been generated at another place.

In Plate IX., Fig. 4 A is the tone transmitter [Tonengeber], and B the tone receiver [Tonenppfanger], and these two instruments are set up at different stations. I must observe at the outset that the arrangement of the instruments for sending backwards and forwards is omitted for greater clearness; and likewise, as the whole thing is not presented as a completed fact, but only to call to the notice of a wider circle what has been already ascertained, the possibility of the working of the apparatus at a distance greater than the limited direct working allows at present is left out of consideration, since these points are easily accomplished by mechanical arrangements, and since the most important facts of the phenomena treated are not influenced thereby.

Let us now turn to the tone transmitter, Fig. 4 A. This on the one hand is connected by the metallic conductor with the tone receiver, Fig. 4 B, at a neighboring station; on the other hand it is connected by means of the electric battery C with the earth (or with the metallic return conductor). The tone transmitter, Fig. 4 A, consists of a conical tube $a\,b$, about 15 centimetres in length, having a front opening of about 10 centimetres, and a rear opening of about 4 centimetres.

1889



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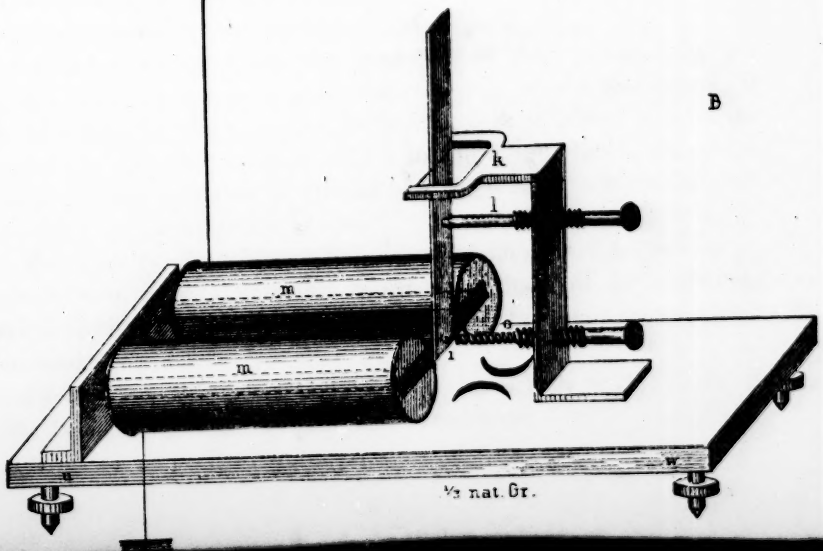
B



⅓ nat. Gr.

(It appears by practical experiments that neither the material of this tube nor any increase in its length influenced the accuracy of the action of the apparatus. An enlargement of the diameter of the tube impairs the working of the apparatus, and it is desirable that the inner surface of the tube be as smooth as possible.) The smaller or rear end of the tube is closed by a collodion membrane *o*, and upon the centre of the circular surface of this membrane rests one end *c* of the lever *c d*, the supporting point *e* of which is sustained by a bracket, and is kept in electrical connection with the metallic conductor. The proper lengths of the respective arms *c e* and *e d* of this lever are regulated by the laws of the lever. It is advisable to make the arm *c e* longer than the arm *e d*, in order that the least motion at *c* may operate with greatest effect at *d*. It is also desirable that the lever itself be made as light as possible, that it may follow the movements of the membrane. Any inaccuracy in the operation of the lever *c d* in this respect will produce false tones at the receiving station. When in a state of rest the contact at *d g* is closed, and a delicate spring *n* maintains the lever in this position.

The second part of the apparatus, the standard *f*, consists of a metallic support, connected with one pole of the battery C, the other pole of which is connected to the earth, or to a metallic return wire leading to the other station.

Upon the standard *f* is arranged a spring *g*, with a contact point corresponding to the contact point *d* of the lever *c d*; the position of *g* is regulated by the screw *h*.

In order not to impair the operation of the apparatus by the action of the air waves against the rear side of the membrane, it is desirable to place upon tube *a b*, a disk of about fifty centimetres in diameter at right angles to the longitudinal axis of the tube *a b*; this disk may be attached to the tube by a fastening surrounding its outer circumference.

The tone receiver, Fig. 4 B, consists of an electro-magnet *m m*, which rests upon a sounding board *u w*; its coil is connected respectively with the metallic conductor and the earth or the metallic return conductor.

Facing the electro-magnet *m m* is an armature, to which is attached a very long but light and broad lever *i*.

The lever *i* with the armature is suspended from the standard *k* in the manner of a pendulum, its motion being regulated by means of the screw *l* and the spring *q*.

In order to increase the effect of the apparatus, the tone receiver may be placed at one of the focal points of an elliptically arched chamber of suitable size, and the listener may place his ear at the other focus of this chamber.

The operation of the apparatus described is as follows: —

When at rest the galvanic circuit [Kette] is closed. When the air, which is in the tube *a b* of the apparatus, Fig. 4 A, is alternately condensed and rarefied, by speaking into it (or by singing or introducing the tones of an instrument), a movement of the membrane closing the smaller opening of the tube is produced, corresponding to such condensation or rarefaction. The lever *c d* follows the movements of the membrane, and opens and closes [öffnet und schliesst] the galvanic circuit [Kette] at *d g*, so that at each condensation of the air in the tube the circuit is opened, and at each rarefaction the circuit is closed [ein Oeffnen und ein Schliessen erfolgt].

In consequence of this operation, the electro-magnet of the apparatus, Fig. 4 B, in accordance with the condensations and rarefactions of the column of air in the tube *a b*, Fig. 4 B, is correspondingly demagnetized and magnetized [demagnetisirt und magnetisirt], and the armature of the magnet is set into vibrations like those of the membrane in the transmitting apparatus. But the beam (Balken) *i* attached to the armature communicates these corresponding vibrations of the armature to the air surrounding the apparatus Fig. 4 B, which finally transmits the vibrations so produced to the ear of the listener.

We have not here to consider the question of the transmission [Fortpflanzung] of tones by means of the galvanic current, but only of the conveyance [Uebertragung] of generated sounds to another place, and in this way, that at the latter place a similar cause is produced, and a similar effect obtained. It must not be ignored, however, that while the apparatus described reproduces the exact number of the original vibrations, but not of the same strength [die gleiche Stärke der reproducirten Schningungen noch nicht erreicht

nurde]; and that the achievement of this result is reserved for an improvement of the apparatus.

In consequence of the imperfection of the apparatus at this time, the minor differences of the original vibrations are distinguishable with more difficulty, — that is, the vowel sounds appear more or less indistinct, — inasmuch as each tone depends not merely upon the number of the vibrations of the medium, but also upon its condensation and rarefaction.

This also explains why chords and melodies were transmitted with marvellous accuracy in the practical experiments hitherto made, while single words in reading, speaking, etc., were less distinctly recognizable, although even in these the inflections of the voice, as in interrogation, exclamation, surprise, calling, etc., were clearly reproduced.

There is no doubt that the subject we have been considering, before it becomes practically valuable for use, will require considerable improvement; it will especially be necessary to perfect the mechanism of the apparatus to be employed; but I am convinced, by repeated practical experiments, that it is of the greatest theoretic interest to pursue these investigations, and also that a development of practical value will not elude our intelligent century.

Nos. 13, 14, 15. — Deutsche Industrie Zeitung, Chemnitz, 1863.
[German Industrial Gazette, Chemnitz, 1863.]

No. 13. No. 16, page 184, April 17, 1863: —

"Industrial Queries for Exciting Interest and Eliciting Responses.

"Of late there has been talk in newspapers about producing definite tones at a distance, similarly to telegraphic despatches, such for instance as conducting the acoustic effects of an instrument far beyond the reach of the audibility of its sound. Do these communications rest upon actual facts?"

No. 14. No. 18, page 208, May 1, 1863: —

"Answers. Answer to question in No. 16, page 184. Transmission of tones by Electricity. According to the 'Böttger's Notizblatt,' 1863, No. 6, successful experiments in 'telephony' were made in October, 1861, at Frankfort-a-M., by Prof. Ph. Reis,

so that it seems not impossible to carry on conversations at miles distance, and even to convey the voice itself with its peculiar undulations, and also the tones of a musical instrument. Heretofore the voice could be reproduced from one house to another only for a distance of 300 feet by means of a peculiar and ingenious apparatus. The arrangement of the same was essentially as follows: The waves of sound were taken up by an elastic surface, and transmitted to a light commutator introduced into the circuit of a galvanic battery [einer federnden Commutator eingeschaltet in den Leitungsdraht]. At the other end of the line was introduced a coil of copper wire, inside of which was an iron wire resting upon a sounding board, that was thrown into sonorous vibrations by the changes of current depending upon the waves of sound."

No. 15. No. 22, page 249, May 29, 1863.

"*The reproduction of tones by electro-galvanic means (with a drawing, which is the same as the drawing of the apparatus in the Legat article, No. 12, pp. 23–29, supra).*

"Although this subject has already been discussed by us (No. 18, page 208), on account of the great interest it offers, we shall return to it more in detail. We enclose a drawing of an apparatus used by Mr. Ph. Reis in Frankfort-a-M., taken from the Zeitschrift des Deutch-Oesterreichischen Telegraphen Vereins, 1862, folios 6, 7 and 8. We take the liberty of following the lead of the above-mentioned source in entering into a short discussion of the nature of tones.

"The undulations of the air that excite in us, by operating upon the ear, the sensation of sound, by setting the drum of the ear into vibration, are transmitted, as is well known, by a series of levers of admirable delicacy, that is, by the small bones of the ear (hammer, anvil and stirrup) to the inner portion of the ear and to the nerves that lie at that point. The attempt to reproduce tones depends upon the following: to set in motion an artificial imitation of this series of levers by the vibration of a membrane which takes the place of the drum, and to make use of them to open and close a galvanic circuit which is connected by a metallic conductor with a remote station.

"If we take into consideration the phenomena that take place when

we perceive a sound by the sense of hearing, we find that every tone is the result of rarefactions and condensations of the air repeated several times in a certain period. At every condensation the membrane of the drum is pressed inwards, and at every rarefaction outwards. These vibrations produce a simultaneous motion of the small bones of the ear and a consequent transmission to the nerves of the ear. The greater the compression of the sound-conducting medium at any particular moment, the greater is also the amplitude of vibration of the membrane and small bones of the ear, and *vice versa*. The object, therefore, of the organs of hearing is to transmit with certainty the rarefactions and condensations of the sound-conducting medium to the nerves of hearing. On the other hand, it remains their object to bring to our perception the vibrations occurring in a given time with reference to number as well as to amplitude. It is only in our perceptions that a given combination receives a definite name, that vibrations become sounds.

"Anything other than the effect of such single vibrations the organs of hearing are unable to take up, and these organs themselves are competent to perceive single tones as well as combinations of tones; for if several tones are produced at the same time, the sound-conducting medium is under the influence of several simultaneous forces, which according to the laws of mechanics can be replaced by a force which produces the same effect as all the single ones together. If all the forces operate in the same direction, the magnitude of the motion is proportional to the sum; if they operate in opposite directions, the magnitude of the motion is proportional to the difference of the opposite forces. In that way several simultaneous tones operate upon our hearing simply by a definite alternation of rarefactions and condensations of the sound-conducting medium, as in the case of single tones. The tone itself depends apparently only upon the number of vibrations and the power upon the amplitude of the vibrations (perhaps also the strength).

"Now, as regards the apparatus, the upper figure is the transmitter and the lower one the receiver or reproducer.

"The transmitter consists of a metallic conical pipe *a b*, about 15 centimetres in length, 10 in diameter at *a* and 4 in diameter at *b*. At *b* the opening is closed by a membrane *o* of collodion stretched

tight. Upon the centre of the same rests the end *c* of lever *c d*, whose fulcrum is placed at *e* on a support. The lever is to be made as light as possible, and its arm *c* longer than its arm *d*, so that the smallest motion at *c* will operate at *d* with the greatest amount of force. In the condition of rest the contact *d g* is closed and a weak spring *n* holds the lever fast in this position of rest. Besides, there is attached to the apparatus a metallic standard *f*, connected with one pole of the battery, while the other pole is led to the ground through *e*. On the standard *f* is secured the spring *j* opposite the contact point *d* of lever *c d* at *d*, the position of which (spring) can be regulated by a screw *h*.

"The receiver consists of an electro-magnet *m m* resting upon a sounding board R, and whose coils are in connection with a metallic conductor and with the earth at E. Opposite the electro-magnet is an armature connected with a lever, as long as possible, but light and broad. This lever is fastened to the support *k* after the manner of a pendulum, and its motions are regulated by a screw *b* and spring *g*.

"To increase the efficiency of the apparatus, the receiver and reproducer can be set up in one focus of an elliptical concavity of proper size, while the listening ear of the hearer is placed in the other focus.

"The operation of the apparatus is now as follows: The tones of the voice or of an instrument are conducted into the conical pipe *a b*. By reason of their vibration the membrane is set into similar vibration and in this way operates the opening and closing of the electric conductor. In consequence of this the magnet in the receiver will be magnetized and demagnetized corresponding to the vibration of the tones, and the armature of the lever *i* is set in vibrations corresponding to those of membrane *o*. The wide surface of lever *i* transmits these vibrations to the air, and by this means they reach the ear of the hearer. In this transmission of tones, the only question is one of transmission of vibrations, a problem that magneto-electric telegraphy is certainly sufficiently far advanced to deal with.

"A friendly communication was sent us some time ago by Mr. J. F. Quilling, of Frankfort-a-M., according to which the capacity of the apparatus to transmit tones to a considerable distance clearly and with their characteristic timbre [Klangfarbe] is fully estab.

lished. Mr. Q. writes us that by means of the telegraphic conductor with which the apparatus of Mr. Ph. Reis was connected, two remote parts of the city were united, and although it was not possible with the present construction of the apparatus, to transmit spoken words [gesprochenen Wörte], they succeeded so well with the tones that were sung that not only were the melodies of songs reproduced distinctly and perfectly at a tolerably remote station, but known voices could be recognized. All present capable of judging, Mr. Q. adds, who availed themselves of the opportunity of witnessing the experiment, agreed that the possibility is before us of making one's self understood verbally at any distance in the way shown by Mr. Reis."

No. 16. — Polytechnisches Notizblatt für Gewerbtreibende Fabrikanten und Künstler, Herausgeben von Rudolph Böttger, Mainz [und Frankfurt-a-M.], 1863, No. 61, p. 81.

[Polytechnic Journal for Tradesmen, Manufacturers and Artisans. Published by Rudolph Böttger. Mayence and Frankfort-a-M.]

On the Transmission of Tones at any desired Distance, by Means of Electricity. (*Telephony.*)

Two decades ago we had not reached beyond the first attempts of making signals at considerable distances. Since then, telegraphy has reached such perfection, and telegraph wires have been so extended, that little remains to be asked for by the boldest desires.

Now there appears a first earnest trial to reproduce tones at any desired distance, by means of electricity. This first trial, which has been crowned with success, has been repeated in the lecture room of the Physical Society of Frankfort-on-the-Main, before numerous assembled members, on the 26th of October, 1861, by Mr. Ph. Reis, teacher of natural sciences at Friedrichsdorf, near Frankfort. Into one part of his apparatus located in a building about three hundred feet distant, and having all the doors and windows closed, melodies were sung, but not very loudly. The same could be heard by the members in the lecture room, through the second part of the apparatus.

These wonderful results were attained with the following very

simple apparatus: A small, light box, a kind of hollow wooden cube, has a larger opening in the front, and a smaller one on the opposite side. The latter is covered with a very fine membrane, sausage skin, and the same is tightly stretched; a small flexible piece or strip of platina, fastened to the wood of the box, touches the membrane at its centre, and a second strip of platina is fastened by one end to the wood at a different place, and has at its other end a fine horizontal point touching the other strip of platina, where it lies on the membrane.

As is known, tones are produced by the rapid succession of condensations and rarefactions of the air. If the vibrations of the air, called waves, strike the thin membrane, they push the same against the strip of platina that touches it, and then allow it to immediately vibrate back into the hollow cube (called the artificial ear), and so cause the membrane to assume forms alternately bent towards the cube and from the same. The strip of platina lying against the membrane is thus set into a swinging motion, so that it is alternately pressed on to the platinum point of the second strip and then leaves the same.

If one of the strips is connected by a wire to one of the poles of a voltaic battery, and the electricity is conducted to any desired distance by wire connected to the other pole and is then carried through a helix six inches in length, wound with six layers of thin silk-covered copper wire, and from there is carried back to the second strip of platina on the wooden cube by means of a second insulated wire, then, at every vibration of the membrane, an interruption of the current of electricity [Unterbrechung in der Strömung der Electricität] will be caused, as the point on the one strip of platina no longer touches the other strip. Through the hollow of the helix a thin iron wire (a thick knitting needle) about ten inches in length is passed, so that it projects out of each end of the spiral about two inches, and these projecting ends each rest on a bridge of a sounding board.

It is known that if an electric current is passed through a helix that surrounds an iron wire, in the manner described, at every interruption, a tone, produced by the vibrations of the iron wire, is audible. If the makings and breakings of the current [Unterbrechungen des Stromes] follow each other rather slowly, the different

positions (in regard to the length of the bar) which the molecules will be caused to assume by the electricity, will produce a tone, its so-called proper longitudinal tone which depends on the length and thickness of the bar or wire.

If the makings and breakings of the current [Unterbrechungen des electrischen Stromes] in the spiral take place faster than the vibrations of the smallest parts of the wire, which in turn depends upon the elasticity of the wire, they cannot complete their courses, they receive new shocks, the vibrations get to be smaller but more rapid, and as numerous as the interruptions follow each other. The piece of wire no longer gives its longitudinal tone, but a tone which, according to the number of interruptions in a certain time, is higher if they are more frequent and lower if they are less frequent. It is known that the pitch of a tone depends on the number of air waves that follow each other in one second. We have seen above that the number of interruptions of the electric current [Unterbrechungen des electrischen Stromes] by the membrane and the strips of platina is dependent upon this.

Consequently the iron wire must give a tone of the same pitch as the sound which was received by the membrane. As electricity is hardly impaired when conducted a great distance, if the proper apparatus is used, it is evident that a tone acting on a membrane in one place can be made audible at any desired distance by the iron wire.

That the tone is made audible only by electric vibrations and not by direct transmission of the air waves through the wires, can be most strikingly proved by noticing the fact that no tone is heard at the spiral if a good short circuit be established; *i. e.*, if, for instance, a small strip of metal is laid across the two wires, directly in front of the spiral. The reproduced tones are, indeed, somewhat weaker than the originals, but the number of vibrations is the same. It is easy to reproduce the tones in the proper pitch. As the vibrations are smaller, which is the cause of the weakness of the tone, it is much more difficult, however, for our ear to estimate the difference in the size of the vibrations.

The character of a tone depends upon the number of swellings it has; *i. e.*, with tones of the same depth, consequently of the same

number of waves per second, such as having the fourth, sixth, eighth, tenth or sixteenth wave stronger than the rest.

The physicists have shown that if a spring is vibrated by the teeth of a cog wheel, the first vibration is the greatest, and every following one is smaller. If, however, before the spring comes to rest, another tooth strikes it, then the next vibration will be equal to the first strongest one, but the vibrations of the spring will not be any more numerous than before. Vowel tones can be artificially produced in this way.

Although we may be far from being able to converse with a friend a hundred miles away and recognize his voice, as though he was sitting alongside of us, the impossibility of attaining this result can no more be claimed.

The probability that this result will be attained is almost as great as by the wonderful experiments of Niepce, the reproduction of natural colors by photography.

No. 17. — FRANKFURTER CONVERSATIONSBLATT, June 30, 1863.
(This is a reprint of Böttger's article, **No. 16,** *supra.*)

No. 18. — DINGLER'S POLYTECHNISCHES JOURNAL, Stuttgart, Vol. CLXVIII. p. 185.
(This is a reprint of Böttger's article, **No. 16,** *supra.*)

No. 19. — POLYTECHNISCHES CENTRALBLATT, Leipzig, 1863, pp. 857–59.
(This is a reprint of Böttger's article, **No. 16,** *supra.*)

No. 20. — JAHRESBERICHT DES PHYSICALISCHEN VEREINS ZU FRANKFURT AM MAIN, für das Rechnungs Jahr 1862–1863, p 35.

[Yearly Report of the Physical Society of Frankfort on the Main]

Page 35. "The following lectures were also delivered in the Saturday proceedings, to wit: November 29, 1862, by Dr. Keil, of Langensalza, on magnetism in general; on the maufacture of artifi-

1900

cial steel magnets by the hitherto customary processes, and also a statement of a new method of making magnets by stroking; and July 4, 1863, by Mr. Ph. Reis, of Friedrichsdorf, teacher, on the transmission of tones to desired distances by means of electricity; the paper being accompanied with an exhibition of an improved telephone, and the performance of experiments with it." [The paper was not printed.]

1869–70, p. 26. A long article entitled "Geschichtliches über den physikalischen Verein," by J. Walled, contains the following: "P. Reis was the author [in 1861] of a treatise on Telephony by means of the galvanic current."

No. 21. — JOURNAL OF THE SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS, London, March, 1883, No. 46.

REIS'S TELEPHONE.

The following is a copy of an autograph description of Reis's telephone which has been presented to the library by Mr. Wm. Ladd, Member: —

(Copy.)

INSTITUT GARNIER,
FRIEDRICHSDORF.

Dear Sir:

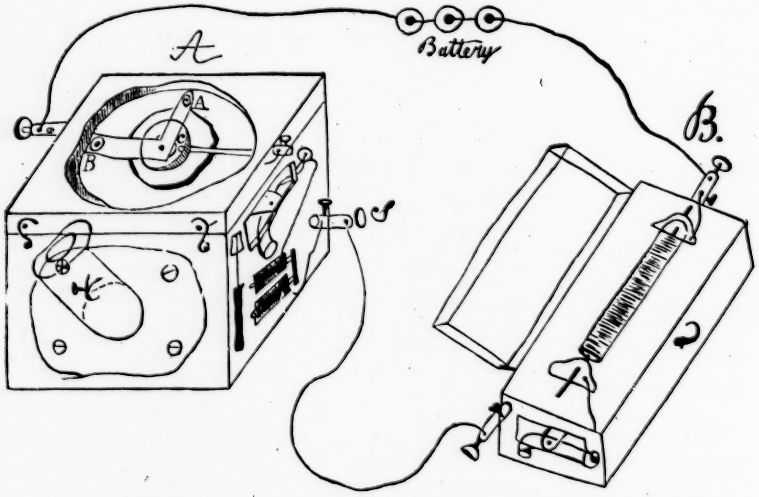
I am very sorry not to have been in Francfort when you were there at Mr. Albert's, by whom I have been informed that you have purchased one of my newly-invented instruments (Telephons), though I will do all in my power to give you the most ample explanations on the subject. I am sure that personal communication would have been preferable, specially as I was told that you will show the apparatus at your next scientifical meeting, and thus introduce the apparatus in your country.

Tunes and sounds of any kind are only brought to our conception by the condensations and rarefactions of air or any other medium in which we may find ourselves. By every condensation the tympanum of our ear is pressed inwards, by every rarefaction it is pressed outward, and thus the tympanum performs oscillations like a pendulum.

The smaller or greater number of the oscillations made in a second gives us, by help of the small bones in our ear and the auditory nerve, the idea of a higher or lower tune.

It was no hard labor, either to imagine that any other membrane beside that of our ear could be brought to make similar oscillations, if spanned in a proper manner and if taken in good proportions, or to make use of these oscillations for the interruption of a galvanic current. However, these were the principles which guided me in my invention; they were sufficient to induce me to try the reproduction of tunes at any distance. It would be long to relate all the fruitless attempts I made until I found out the proportions of the instrument and the necessary tension of the membrane. The apparatus you have bought is now what may be found most simple, and works without failing when arranged carefully in the following manner: —

The apparatus consists of two separated parts, one for the singing station, A, and the other for the hearing station, B.



Reis's Telephonic Apparatus.—Facsimile of Drawing sent by Reis to Mr. Ladd.

The apparatus A is a square box of wood, the cover of which shows the membrane *c*, on the outside, under glass. In the middle of the latter is fixed a small platina plate to which a flattened copper wire is soldered, on purpose to conduct the galvanic current. Within the circle you will further remark two screws: one of them is termi-

nated by a little pit in which you put a little drop of quicksilver; the other is pointed. The angle, which you will find lying on the membrane, is to be placed according to the letters, with the little hole *a* on the point *a*, the little platina foot *b* into the quicksilver; screw; the other platina foot will then come on the platina plate in the middle of the membrane.

The galvanic current coming from the battery (which I compose generally of three or four good elements) is introduced at the conducting screw near *b*, wherefrom it proceeds to the quicksilver, the movable angle, the platina plate and the complementary telegraph to the conducting screw *s*. From here it goes through the conductor to the other station B, and from there returns to the battery.

The apparatus B, a sonorous box on the cover of which is fixed the wire spiral with the steel axis, which will be magnetic when the current goes through the spiral. A second little box is fixed on the first one, and laid down on the steel axis to increase the intensity of the reproduced sounds. On the small side of the lower box you will find the corresponding part of the complementary telegraph.

If a person sing at the station A, in the tube *x*, the vibrations of air will pass into the box and move the membrane above; thereby the platina foot *c* of the movable angle will be lifted up, and thus will open the stream at every condensation of air in the box. The stream will be re-established at every rarefaction. In this manner the steel axis at station B will be magnetic once for every full vibration, and as magnetism never enters nor leaves a metal without disturbing the equilibrium of the atoms, the steel axis at station B must repeat the vibrations at station A, and then reproduce the sounds which caused them. *Any* sound will be reproduced if strong enough to set the membrane in motion.

The little telegraph which you find on the side of the apparatus is very useful and agreeable for to give signals between both of the correspondents. At every opening of the stream, and next following shutting, the station A will hear a little clap, produced by the attraction of the steel spring. Another little clap will be heard at station B in the wire spiral. By multiplying the claps and producing them in different measures, you will be able as well as I am to get understood by your correspondent.

I am to end, sir, and I hope that what I said will be sufficient to have a first try; afterwards you will get on quite alone.

I am, sir,

Your most obedient servant,

PH. REIS.

FRIEDRICHSDORF, 13/7,63.

To Mr. WILLIAM LADD.

No. 22.—THE NEWCASTLE DAILY CHRONICLE AND NORTHERN COUNTIES ADVERTISER.

(*Report of British Association Meeting.*)

SATURDAY, August 29, 1863.

SECTIONAL MEETINGS.

(Yesterday.)

A.—Mathematical and Physical Science.

President: W. J. Macquorn Rankine, C. E., F. R. S.

Vice-Presidents: General Sabine; Professor Sylvester; and W. Spottiswoode, F. R. S.

Secretaries: Professor Stevelly, LL. D.; Rev. C. T. Whitley, M. A.; Professor H. I. S. Smith, M. A., F. R. S.; Professor Fuller; and the Rev. W. Ferrers.

Mr. Ladd then exhibited an acoustic telegraph for the transmission of musical notes and sounds between distant points, this ingenious contrivance being the invention of a schoolmaster at Frankfort, whom Mr. Ladd had met with in his travels. By means of this telegraph, sounds were transmitted from one end of the table to the other, the sounds (which are produced by the principle of vibration) being heard fainter than they were uttered. Mr. Ladd, however, expressed his opinion that distance would not militate against the power of the telegraph to transmit sound. At the same time, he admitted it was of no practical use, but was merely a scientific toy.

Professor Stevelly said that Mr. Ladd might be able to talk through his telegraph.

Mr. JENKYN.—He may whistle a tune through it, at any rate.

1904

No. 23. — The Civil Engineer and Architect's Journal, London, Vol. XXVI., pp. 307–8, 1863.

An Acoustic Telegraph (*paper read to the British Association*, 1863), *by* W. Ladd.

Having met with an ingenious telegraph instrument, when recently in Frankfort, the invention of a schoolmaster near that place, a description may not be uninteresting to the physical section; and if it does not come up in efficiency to some of the instruments in use, I can only say that novelty is very often a step to improvement.

The instruments for transmitting and receiving the sounds consist essentially of two distinct pieces of apparatus: that for transmitting, measures four inches cube, and has a small mouthpiece or speaking pipe projecting from the front; on the right-hand side there is a small finger key, forming part of the circuit, and also an electromagnet with a vibrating armature and binding screw to connect with one of the line wires. Within the case under a glass cover is an elastic membrane, in the centre of which there is fixed a small platinum plate; this by means of a wire is always in connection with the finger key on the outside of the case. There is a light piece of angular metal somewhat in the form of the letter L, resting on three pins, and so placed that the pin at the angle rests on the plate in the centre of the membrane, the other two pins rest in cups on its edge, so as to allow of free motion on the points. In one of the cups there is placed a drop of mercury to insure metallic contact, and this is in connection with a binding screw on the left-hand side of the case.

The receiving instrument consists of a light wooden box, measuring about ten inches long by three inches square, on one end of which there is fixed a binding screw and finger break, similar to the one on the transmitter. In the body of the box there is suspended from two wooden bridges a soft iron core, surrounded by a coil of silk-covered wire, one end of which is in connection with the finger key, and the other end with a binding screw at the left-hand side of the box.

The method of producing sound in the receiving instrument depends

upon the fact, that at the moment of magnetizing and demagnetizing a piece of iron there is an alteration in the arrangement of the particles, which can be distinctly heard by a slight ticking noise. Advantage is taken of this fact by placing the iron core in the box, so that it can be magnetized and demagnetized at pleasure, the box simply acting as a sound board. The method of working this telegraph is as follows: —

Having connected one of the binding screws in the transmitter by means of an insulated wire, with one of the binding screws on the receiver, and the other binding screws being brought in connection with a battery of three or four elements, the telegraph is ready for work.

If you then press the finger key on the transmitter, the person at the receiving station will immediately hear a tick at his instrument, for every time the current is broken; this is produced, as explained, by the alteration of the magnetic state of the iron core, by the alternate suspension and transmission of the electric current through the helix surrounding it. And as all musical notes are simply the production of pulsations at regular intervals, we have simply to find some means of making and breaking contact a number of times equal to the pulsations of the note to be conveyed to receiver; this is ingeniously fulfilled by the elastic membrane in the transmitting instrument.

The operator has simply to place his mouth to the tube in front of the instrument and sing a note, when immediately the membrane begins vibrating in accordance with the note sounded, and at each vibration breaks contact between the pin and the plate in its centre; this forming part of the circuit, causes the iron core in the receiving instrument to be magnetized and demagnetized a number of times, equal to the number of vibrations of the membrane, and so conveys to the receiver an impression of a musical note.

The finger keys and small magnet at the sides of the instruments are for the purpose of varying the methods of communication by the combination of single sounds, and can also be used, with the other parts, for the purpose of regulating the lengths of the notes, and dividing them into varying portions, so as to form a sound alphabet somewhat similar to the signals written by Morse's telegraph.

1906

No. 24. — REPORT OF THE THIRTY-THIRD MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, IN AUGUST AND SEPTEMBER, 1863; published 1864.

On an Acoustic Telegraph, by W. LADD.

This instrument consists, essentially, of two distinct pieces of apparatus; that for transmitting the signal has a small mouthpiece. On the right-hand side there is a finger key forming part of the circuit, and an electro-magnet, with a vibrating armature and binding screw to connect with one of the line wires. Within a case under a glass cover is an elastic membrane, in the centre of which is fixed a platinum plate in connection with the finger key. A like piece of angular metal resting on three pins is so placed that the pin at the angle rests on the plate in the centre of the membrane, the other two resting in cups on its edge so as to allow a free motion on the points. In the body of the receiver box is suspended a soft iron core surrounded by a coil of silk-covered wire, one end of which is in connection with a finger key and the other with the binding screw. The method of producing sound in the receiving instrument depends upon the fact that at the moment of magnetizing or demagnetizing a piece of iron there is an alteration in the arrangement of the particles, which gives rise to a slight ticking noise Having connected the transmitter by means of an insulated wire with the receiver, and the binding screws having been brought in connection with a battery of three or four elements, if the finger key on the transmitter be pressed, the person at the receiving station hears the ticking noise. To convey a musical note or sound, the operator places his mouth to the tube in front of the instrument and sings a note, when immediately the membrane begins vibrating in accordance with the note sounded, and at each vibration breaks contact between the pin and plate in its centre. This forming part of the circuit causes the iron core in the receiving instrument to be magnetized and demagnetized a number of times equal to the number of vibrations of the membrane, and so conveys to the receiver an impression of a musical sound. The finger keys and small magnet at the sides of the instruments are for the purpose of varying the methods of communication by the combination of single sounds, and can also be used with the other parts for the purpose of regulating the lengths of the notes and dividing them into varying portions, so as to form a sound alphabet somewhat similar to the signals written by Morse's telegraph.

No. 25. — PROSPECTUS OF J. WILH. ALBERT, FRANKFORT-ON-THE-MAIN, AUGUST, 1863.

J. WILH. ALBERT,
Mechanician,
Frankfort-on-the-Main.

FRANKFORT-A-M., August, 1863.

Sir, — I take the liberty of sending you the accompanying prospectus, begging you to give it your kind attention; it relates to the very interesting apparatus of Mr. Reis, for the production of tones with the aid of galvanism:

THE TELEPHONE.

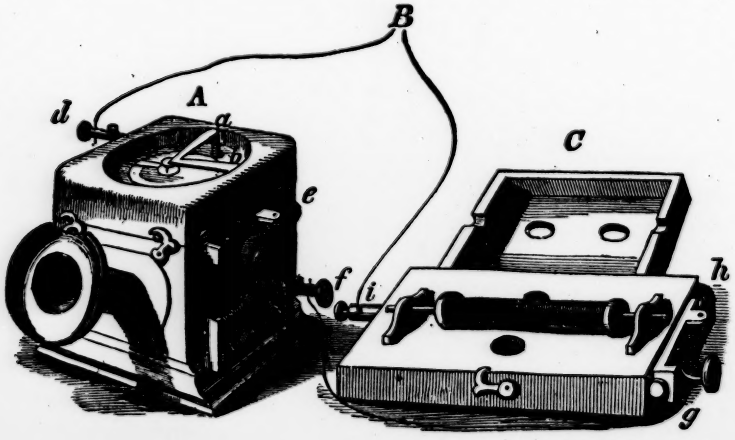
This apparatus, which can be had through me, is at all times exhibited for inspection at my warehouse, and besides I am quite willing to give every information regarding it. My warehouse of physical, optical and chemical instruments and apparatus is now: Neue Mainzerstrasse-No. 34 AM. Taunusthor, only three minutes' walk from the several railroad stations, and therefore may be visited by any one, however short his stay in Frankfort may be.

Awaiting your kind order, I am, Respectfully yours,

J. WILH. ALBERT.

No. 26. — REIS'S CIRCULAR OF AUGUST, 1863.

(This is on the same sheet of paper as the foregoing.)



1908

Sir, — Having succeeded two years ago in demonstrating the possibility of reproducing tones with the aid of the galvanic current and in manufacturing an apparatus for that purpose, the subject has been so highly appreciated by the most renowned men of science, and I have received so many encouragements, that I have striven since that time to improve my originally very imperfect apparatus, in order to give to others also the facility of experimenting.

I am now able to offer an apparatus which satisfies my expectations, and with which every physicist will succeed in repeating these interesting experiments regarding the reproduction of tone (Tonreproduction) at distant stations.

I believe that it is the wish of many that these instruments should come into the possession of laboratories; as, however, their manufacture demands a complete knowledge of the leading principles and a great experience in this matter, I have resolved to make the most important part myself, and to intrust to the mechanician only the secondary parts and the external outfit. Mr. J. Wilh. Albert, mechanician at Frankfort on the Main, is commissioned to sell them. I have enabled him to offer them at the prices of 21 and 14 florins (12 and 8 Prussian thalers) in two qualities, which differ only in the external outfit. The instruments can also be had directly from me at the same price by cash payment. Every apparatus is examined by me before being shipped, and has attached my name, the serial number and the date of construction.

FRIEDRICHSDORF b. HOMBURG, v. d. HÖHE, AUGUST, 1863.

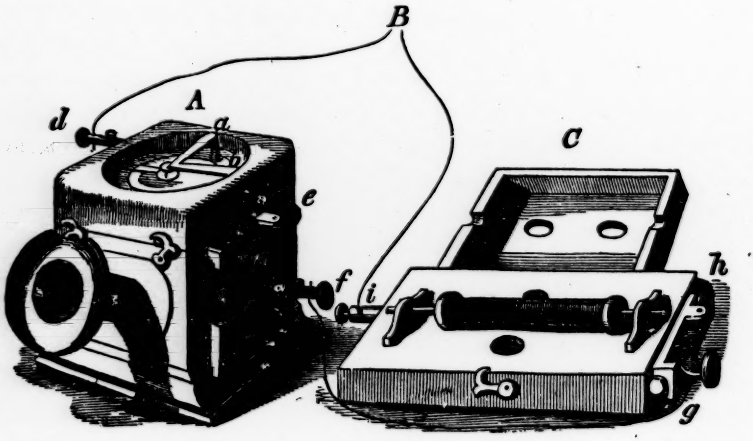
PHIL. REIS,
Teacher at L. F. Garnier's Boys' Institute.

(In manuscript on the foregoing is the following: —)

Descriptions of the above are to be found in Müller-Pouillet's Lehrbuch der Physik, Braunschweig, Vieweg & Son; Pisko, die Neueren Apparate der Akustik, Wein, Gerold's Son, 1865.

No. 27. — REIS'S DESCRIPTIVE CIRCULAR, 9 AUGUST, 1863.

(This and the foregoing are on two similar printed sheets.



TELEPHONE.

The apparatus consists of two parts, as may be seen in the wood-cuts above, the telephone proper A, and the reproducing apparatus C. These two parts are to be placed at such a distance from each other that singing or the sound of a musical instrument can be heard in no other manner except through the apparatus from one station to another.

Both parts are connected with each other and with the battery B, the same as in an ordinary telegraph. The battery must be sufficient to produce at station A the attraction of the armature of the electro-magnet placed at one side (three or four six-inch Bunsen cells are sufficient for several hundred feet of distance).

The galvanic current then goes from B to the binding post *d*, from there through the copper strip, to the platina disk in the centre of the membrane, then through the foot *c* of the angle towards the binding post B, *in the small hollow of which a drop of quicksilver is inserted*. From here the current goes through the small telegraph apparatus *e f*, then to the key of the station C and through the coil surrounding *i* back to B.

1910

If now sufficiently strong tones are produced before the mouthpiece, their vibrations will put in motion the membrane and the angular little hammer [winkelförmige Hämmerchen] which lies on it; for every full vibration the circuit is once opened and again closed [einmal geöfnet und wieder geschlossen], and thereby are produced at station C in the core of the coil, just the same number of vibrations [ebensoviele Schwingungen hervor-gebracht] which are there perceived as tones or as combinations of tones [Accords]. By placing the cover tightly over the axis of the coil, the tones at C are greatly strengthened. Besides the human voice [menlischen Stimme] there can be reproduced (according to my experience) just as well the tones [Töne] of good organ pipes from F to C and those of the piano; to that end the box *a* must be placed on the sounding board of the piano; out of thirteen chords a skilled experimenter could make out ten clearly. The telegraph apparatus placed on one side is evidently unnecessary for the reproduction of tones, but it is a very useful addition for convenient experimenting. With its aid it is possible to easily and surely make one's self intelligible [sich verständigen] with the person at the other station.

This may be done somewhat in the following simple manner: After the apparatus has been put up completely, one satisfies one's self of the continuity of the connection and the strength of the battery by opening and closing the circuit whereby at A is heard a striking of the armature and at C a very perceptible ticking of the coil.

By a quick succession of makes and breaks at A, C is asked whether he is ready for experimenting, whereupon C answers in the same manner.

By agreement between the two stations simple signals can be given by opening and closing the circuit 1, 2, 3 or 4 times, *e. g.*, one stroke — sing: two strokes — speak, etc.

I telegraph words by numbering the letters of the alphabet and communicating their numbers.

1 stroke A,
2 strokes B,
3 strokes C,
4 strokes D,
5 strokes E, etc.

Z would consequently be indicated by 25 strokes.

But these numbers of strokes would take too much time and not be sure in counting. Therefore I put a dactyl for every 5 strokes, hence

— U U for E,

— U U and 1 stroke for F, etc.

Z: – UU – UU – UU – UU – UU, which is quicker, and more easily executed and better understood.

Still better is it to indicate the letters by numbers which are in inverse proportion to the frequency of their occurrence.

9 AUGUST, 1863, FRIEDRICHSDORF, *b.* HOMBURG, *v. d.* HÖHE.

PHIL. REIS,
Teacher of A. L. Garnier's Boys' Institute.

No. 28. — DINGLER'S POLYTECHNISCHES JOURNAL, Stuttgart, Vol. CLXIX., p. 23.

(This is a reprint of the Legat Article, **No. 12,** *supra.*)

No. 29. — B TTGER'S POLYTECHNISCHES NOTIZBLATT, 1863, No. 15, p. 225.

(A copy of this article is printed next below, as **No. 30.**)

No. 30. — DINGLER'S POLYTECHNISCHES JOURNAL, Stuttgart, Vol. CLXIX., p. 399.

CONCERNING THE IMPROVED TELEPHONE.

In the meeting of the Physical Society, held on July 4, at Frankfort-a-M., a member of the society, Mr. Philip Reis, from Friedrichsdorf, near Homburg before the Heights, exhibited some of his improved telephones (Apparatus for the reproduction of Tones at any desired distance by means of the Galvanic Current). It is two years since Mr. Reis first gave publicity to his apparatus, and although the performances of the same in their simply primitive form were astonishing, yet they had this great defect, that experimenting with the same was possible only for the inventor. The instruments exhibited in the above-mentioned meeting scarcely reminded one of the earlier forms.

Mr. Reis has striven to give the same a form pleasing to the eye, so that they now will worthily fill a place in every physical cabinet. This new apparatus can now be easily managed (worked) by every one, and works with great certainty. Melodies sung quite lightly at a distance of about three hundred feet were reproduced by the instrument set up much more distinctly than formerly. The musical scale was especially sharply reproduced.

The experimenters could even reproduce words, although, indeed, only such as had been often heard by them.

In order now that others, less experienced, may be able to even make themselves understood through the apparatus, the inventor has fixed at the side of the same a small, yet, according to his explanation, entirely sufficient arrangement, whose speed of communication indeed is not so great as that of the more recent telegraphs, but which works very surely, and assumes no especial skill in the person working it. We would call the attention of gentlemen busying themselves with physics to the fact that the inventor now has this interesting apparatus manufactured for sale under his supervision (the principal [important] parts he makes himself), and the same can be had of him directly or through the instrument maker, Wilhelm Albert, at Frankfort-on-the-Main, in two qualities, differing only in outward finish, at 14 and 21 florins, respectively (Böttger's Polytechn. Notizblatt, 1863, No. 15).

No. 31. — Die Fortschritte der Physik, Berlin, 1863, p. 96.

Ph. Reis Improved Telephone (Dingler, CLXIX., 399).

Herr Reis is said to have improved, quite essentially, his telephone. With the former instrument, experimentation was possible at the hands of the inventor himself, only.

The instrument (to be had at Albert's, in Frankfurt-a-M., for 14–21 fl.) has now, it is reported, a shape more pleasing to the eye, and can be operated easily by any one. At a distance of three hundred feet, tunes were reproduced far more distinctly than ever before. The scales are reproduced with peculiar precision. The experimenters were able even to communicate words, only such, however, as had been already often heard by them.

No. 32. — THE MEDICAL PRESS, Dublin, Vol. L., No. 1293, p. 471, Wednesday, October 14, 1863.

An extraordinary invention has been planned and perfected, — namely, telegraphing by voice to vast distances, say between London and Liverpool. The operator places his mouth to the tube in front of the instrument and sings a note, when immediately the membrane begins vibrating, in accordance with the note sounded, and causes the iron core in the receiving instrument at the other end to be magnetized and demagnetized a number of times equal to the number of vibrations of the membrane, and so conveys to the receiver an impression of a musical sound the same as transmitted at the other end. This, it is hoped, will extend from vocal tones to verbal tones.

No. 33. — COSMOS, LES MONDES. REVUE HEBDOMADAIRE DES SCIENCES ET DE LEURS APPLICATIONS AUX ARTS ET A L'INDUSTRIE, Redigé par l'abbé Moigno, Paris, Vol. XXIII., p. 705, December 25, 1863.

[A weekly Review of Science and its Application in the Arts and Industries. Edited by the Abbé Moigno, Paris.]

[NOTE. — Before the issue of Vol. XXXIII., the title of this periodical was *Les Mondes.*]

Note by M. Koenig.

Acoustic Telegraphy. There has been introduced and constructed in England, an electric telegraph apparatus which permits the notes of the human voice to be transmitted from one point to another very distant one. The operator places himself before the instrument and sings into the tube any note whatever. A membrane stretched near to the tube, so as to vibrate under the influence of the note sung, is put in connection by a wire conductor with another membrane placed in the same conditions at the station to which one speaks

The number of the vibrations of the first membrane corresponds exactly to the opening or the interruption of the electric current transmitted by the wire conductor to the opposite membrane; this one under the influence of the current, vibrates in unison with the first and renders also a sound identical with the sound sung. There is but one more

1914

step to make, adds the Dublin *Medical Press*, and one will be able to speak, in the proper sense of the word, from one end of the earth to the other.

No. 34. — ZEITSCHRIFT DES ARCHITECTUR UND INGENIEUR VEREINS, Vol. XII., p. 147.

[Journal of the Society of Architects and Engineers for the Kingdom of Hanover, Vol. XII., p. 147, 1866.]

The Dublin *Medical Press* publishes an article upon the new apparatus which permits the sound of the human voice to be transmitted to remote places. A person speaks into a tube near which a membrane is stretched; the vibrations will be carried through the conducting wire to a similar membrane at the receiving station ("End station"). By means of the same vibrations the same sounds will be produced, and so shall it be possible, in fact, to carry on a conversation with another part of the world. Compare this report with Dingler's, Part 4, 1864.

No. 35.—DIE GARTENLAUBE, ILLUSTRIRTES FAMILIENBLATT, Leipzig, No. 51, 1863.

[An lustrated family paper of Leipsic, No. 51, December, 1863.]

Der Musiktelegraph (The Musical Telegraph).

The surprising results in telegraphing have often excited the question whether it may not be possible to communicate the language of sound itself to a distance. The trials made in this direction had till now produced no satisfactory results, because the vibrations of sound-conducting bodies soon diminish so much in force that they are no more perceptible for our senses.

People, perhaps, had already thought of a reproduction of sound at certain distances with the aid of the electric current, but those who have been the best fitted to attack the question, by their knowledge and resources, were the ones who doubted the most of a practical solution of that question. Those who are but superficially acquainted with natural science do not see the many difficulties this

problem offers, if they are at all acquainted with it. Thus, about eleven years ago, a young man, Mr. Philip Reis, at present teacher of natural science at the Garnier Institute for Boys, at Friedrichsdorf, near Homburg, had the hardihood to work at the solution of this problem. But soon he was obliged to desist from it because his very first effort seemed to convince him of the impossibility of a solution. Later, however, after further studies and many experiments, he saw that his first effort was but a rudimentary one, and by no means convincing. However, he did not recommence to attack the question seriously for some time, not feeling himself strong enough to vanquish the obstacles on his road, although he never banished his early idea entirely from his thoughts.

How can a single instrument reproduce simultaneously "the combined effects of all the organs active in human speech"? This seemed to him the chief question. Later he put this question more methodically: "How does our ear perceive the composite vibrations of all the organs of speech acting at the same time?" or, expressed more generally, "How do we perceive the vibrations of several bodies sounding simultaneously?" If we throw a stone into quiet water, there are produced on the surface uniform waves which progress symmetrically outward; the further they go the weaker they become, till they finally disappear.

It is quite similar with that what we call sound and tone. A body made to vibrate through any impulse affects the surrounding air, and causes waves in it, which follow each other at the same rate as the vibrations of the body. As those rings on the water consist in swellings and depressions, so also the vibrations of the air consist of alternate condensations and rarefactions. If they reach our ear, every condensation presses the tympanum towards the interior of the cavity, and puts in motion the adjacent group of small bones which communicates the motion to the liquid of the cochlea, in which the auditory nerves terminate. The latter are excited and produce the *sensation of sound*.

Now, if the waves of vibration follow regularly and with a certain swiftness (sixteen in the second at least), we shall have the sensation of a musical *tone*. The latter is the *higher* the quicker the con-

densations follow each other, and the louder the *stronger* or higher the waves rise, as it were.

Our ear cannot perceive anything except condensations and rarefactions, wave crests and wave hollows. And, nevertheless, we receive the most varied auditory impressions, we distinguish the sound of the voices, we hear at the same time in quite different directions and can distinguish the different sources; nay, in a complete large orchestra, each of the numerous instruments is specially noticed by its peculiar sound, so that we decompose at every moment the total impression into its several parts, according to the height and depth, strength and weakness, or according to the timbre (or quality) [Klangfarbe].

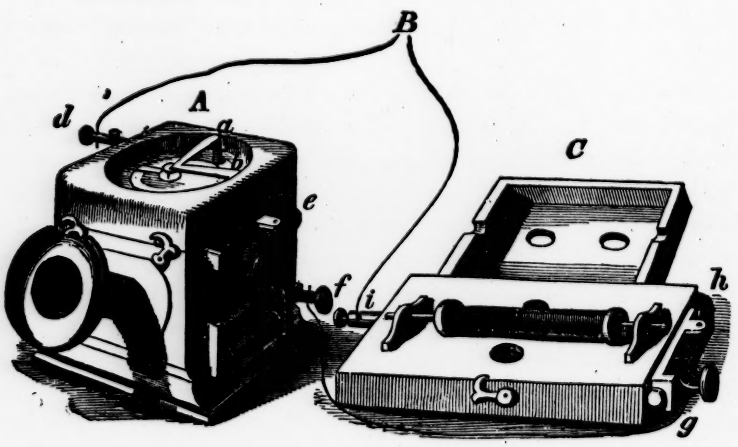
Referring to our simile, this is about the same as if we throw two or more stones at different places into a calm pond. The wave lines cross each other, strengthen each other at some points, weaken each other at others, and the surface has a ruffled, hillocked aspect. But, nevertheless, our eye can detect the different systems of rings, and can trace them back to their several causes. If we succeed in transmitting with the galvanic current the oscillations of a sounding body to a distance, so that there another body is put to equally rapid and, in respect to each other, equally strong oscillations, the problem of "telephoning" is solved.

For then exactly the same phenomena of waves are called forth on the distant points as the ear receives at the place of origin; therefore they also must make the same impression. The ear will distinguish at the distant points not only the single tones, according to their varying height and depth, but also to the proportionate force of the vibrations, and not only single melodies, but the performance of a whole orchestra; yes, even speech must be heard at the same time in places very distant from each other. Mr. Reis was the first one to prove by experiments the possibility of solving this problem. He has succeeded in constructing an apparatus to which he gives the name *Telephone*, and which enables one to reproduce tones, with the aid of electricity, at any given distance. Already, in October, 1861, he made rather successful experiments with a very simple, rudely made apparatus, before a numerous audience at Frankfort. On July 4th of the present year he presented an essentially improved appar-

tus at an assembly of the "Physical Union," which transmitted by closed doors and windows a melody sung moderately loud, to a distance of about three hundred feet, so that it could *be heard plainly*.

In order to give an opportunity to larger circles, especially to scientific men, to convince themselves of the efficiency of this essentially improved apparatus, Professor Böttger, of Frankfort-a-M., made lately (at an assembly of German physicists and doctors in Stettin, in the sectional meetings for natural sciences) several experiments which certainly would have been crowned with still more success if the hall in which the session was held had been located in a less noisy part of the city and filled with a less numerous audience.

Although, for the present, we are not so far along as to be able to converse with a friend at a distance of several hundred miles, so much at least is certain, that with the aid of the telephone, songs of all kinds, melodies, especially in the middle registers, can be reproduced most clearly at unlimited distances. These wonderful results are obtained with the following simple apparatus, which we show here in one fourth of its size: —



A small box A (the telephone proper), a kind of hollow cube, has a mouthpiece S on the front side, and a somewhat smaller opening on the upper side of the box. The latter is closed with a fine membrane

(skin from the intestines of a hog) tightly stretched. A narrow strip of platina *m*, connected with the screw post *d*, touches directly the membrane on its centre; a slender platina point *k*, attached to the angle *a b*, touches the strip of platina which rests on the membrane. If one sings into the mouthpiece S (by filling the same entirely with the mouth), the thin membrane vibrates and the attached platina strip receives likewise a vibrating motion so that it is alternately pressed against and leaves the platina point *k*.

From the binding post *d*, which communicates with the platina strip resting on the membrane, a conducting wire is connected with one of the poles of a galvanic battery B (about three to four six-inch Bunsen elements), and then the electricity is led through a wire attached to the second pole of the battery to the distant station C; there at *i* it passes through a coil *l l* formed of copper wire covered with silk thread, then back again to screw *f*, and there to the platina point *k*. At every vibration of the membrane an interruption of the electric current [unterbrechung des electrischen Stromes] takes place by the platina point parting from the platina strip.

Within the wire coil at station C is a thin iron wire (a strong knitting needle) which is about ten inches long, and which with its two ends projecting out of the coil for about two inches, each rests on two bridges of a sounding box. This is the *reproducing* apparatus.

At every interruption of the current [Unterbrechung des Stromes] in the coil the iron rod is made to vibrate. If the motions follow with a certain rapidity they produce a tone which is rendered audible by the sounding box. As the rate of the interruptions depends on the pitch of the tone that has been sung into the mouthpiece, the same tone is sounded with the same pitch from the sounding box. The length of the circuit has no influence upon this. It is true the electric current loses force the farther it goes, but there is no reason why relays should not be employed, the same as in telegraphing, and with their aid any number of reproducing apparatuses be set into simultaneous vibrations. Mr. Reis has endeavored to give to his improved apparatus a form which should also be pleasing to the eye, so that it might fill worthily its place in any physical laboratory. He has applied, moreover, to the side of the telephone, as well as to

tus at an assembly of the "Physical Union," which transmitted by closed doors and windows a melody sung moderately loud, to a distance of about three hundred feet, so that it could *be heard plainly*.

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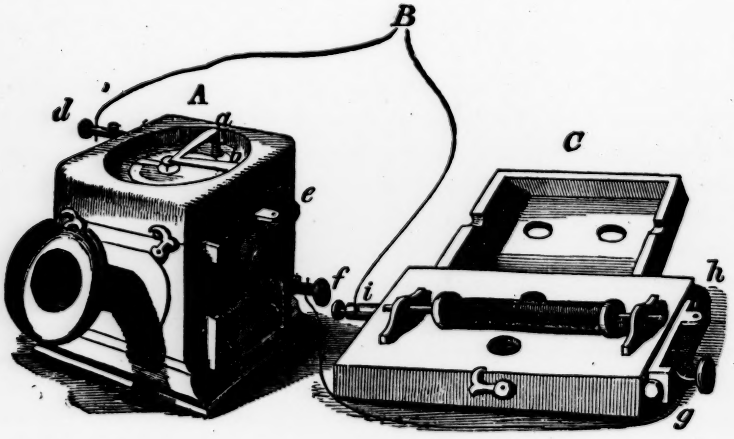

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the reproducing apparatus, a small telegraph arrangement, which is a very good addition for convenient experimenting. (It is indicated in the drawing by the letters *e f h g*.) By alternately opening and closing the circuit with the key *e* or *h* the most varied signals may be given after mutual agreement; for instance, if one is ready for singing; if everything has been understood; whether one should stop singing or commence anew, etc.

Mr. Reis himself manufactures the principal parts of the telephone, for which no small amount of physical knowledge and experience is necessary. The mechanician, Wilhelm Albert, at Frankfort, is charged with manufacturing the less important parts and the external outfit, as well as with the sale of the instrument at a low price.

No. 36.—Cosmos, Vol. XXIV., pp. 349, 352. Published at Paris, March 22, 1864.

[For full title of this periodical, see **No. 33**, *supra*.]

GENERAL PHYSICS: ACOUSTICS.

The Acoustic Telegraph or Telephone of Mr. Th. Ries.

In 1837 Mr. Page observed for the first time the phenomenon of the production of sound by electricity, when the poles of a magnet were rapidly brought near to and moved away from a helix of insulated conducting wire through which an electrical current was passing. M. Delezenne produced an analogous effect by turning an armature of soft iron before the poles of a magnet. The particular phenomenon with a helix was observed separately by MM. de La Rive, Beatson and Marriani. Each of these physicists made upon this subject their own special remarks. M. de La Rive attributed the sound produced to the kind of shock which took place upon the sudden displacement of the molecules at the moment when the current produced its appropriate action. It would therefore be possible to increase the intensity of the effect produced by multiplying the intermittences in the passage of the current. It is in this way that the learned professor of Geneva was able to produce a sound both clear and prolonged, from a cylindrical mass of iron ten centimetres in diameter and weighing ten kilogrammes. M. Marriani recognized,

1920

on his part, that the sound created by a bar of iron placed in these conditions was the same as that which it would give forth if it was thrown into vibration by blows which affected it at its extremity. None of the non-magnetic metals produced any effect of the kind. As to the coercitive force, M. Marriani establishes that a bar of steel, well tempered, would make no sound, but that on the contrary the phenomena manifested itself when it was annealed. M. Beatson and M. de La Rive observed also that an intermittent current passed through a stretched wire made it produce [*rendu*] a sound identical with that which it would give forth if it were placed in the interior of a helix. According to M. de La Rive, the sound was more intense as the wire was made shorter and according as its electrical resistance came nearer to that of the battery employed.

M. Wertheim rendered sensible to the ear the vibrations which result from the passage of a discontinuous electric current through a rigid bar.

In these various experiments, in addition to the musical sound, the observer perceived a succession of blows (*battements*) which coincided with the interruptions of the current. M. de La Rive compared them to the noise which drops of rain made on falling upon a metal roof. These successive blows would even be obtained on operating upon magnetic metals reduced to a powder. The sound produced by iron when the current passes in the magnetizing helix is explained by M. de La Rive as follows: —

"The current tends to place the molecules of the iron in a longitudinal direction; these tend to return afterwards to their normal position, hence the vibrational movement which gives rise to the sound."

It is on the basis of these facts that Mr. Ries has constructed the *telephone* or *acoustic telegraph*. Fantastic minds have singularly exalted the qualities of this apparatus; they have undertaken to indicate for it at once an office which it is far from being able to fill. The exaggerations of these illusions have been demonstrated to us by experiments which we have just made at Mr. Koenig's establishment with an apparatus constructed in Germany, under the supervis-

ion of Mr. Ries. This physicist has constructed his *telephone* in the following manner: —

The transmitter (manipulator) is represented by a rectangular hollow box. One of the sides of this is provided with a mouthpiece [*embouchure*] intended to receive the note which was to be transmitted. The upper surface of it consists of a membrane suitably stretched, on the centre of which is fixed a strip of platinum, which is in electrical connection with one of the poles of the battery. Above this there is placed a second and movable strip which, when the instrument is not in operation, rests on the first by a fine point making contact by a fine point, also of platinum. It will readily be understood that if the membrane vibrates, it will throw up into the air the movable strip, which will again fall back into place. Hence oscillations which will correspond in number exactly with those of the membrane. The receiver is composed simply of a magnetizing helix, in the interior of which is placed a bar of soft iron; the whole is mounted on a resonating [*renforçant*] box. When the apparatus is to be operated, these two instruments are placed in the circuit with an ordinary line battery. The operation of the instrument is easy to understand. The vibrations which the operator placed in front of the mouthpiece impresses upon the air enclosed in the box of the transmitter are repeated by the membrane; and just as a style fixed on this membrane (as in the phonautograph) would write these vibrations upon a paper covered with lampblack, so in the same manner the electrical contacts are successively established and broken between the two strips of platinum. Hence, there is caused in the coil of the receiver a number of intermittences or interruptions in the passage of the current, which is necessarily equal to the number of vibrations of the membrane of the transmitter. Now, since each intermittation causes one single shock, a series must necessarily produce a sound identical in pitch with that produced at the mouthpiece of the transmitter. Would not the telephone of Mr. Ries be an admirable instrument if it realized absolutely the promises which its theory holds out? Without prejudging the future, we must recognize that it has not yet done so. When one sings the musical scale at the transmitter, there needs an ear well trained to distinguish the sound repeated by the receiver in the midst of the vibrations which agitate it. For ourselves we have been only able to recognize the

successive rise of pitch of these rapid roulades; but perhaps a musician would be able to recognize amongst them a dominant note. The model, however, of which we speak, had in its construction several causes of error; and Mr. Koenig, so justly recognized in matters of acoustics, intends to study out the improvements of which this telephone is susceptible.

Let us mention some of the principal of these causes of error: It may be that the membrane will not at every moment vibrate with the same degree of amplitude, and this will consequently occasion sometimes a failure to make contact; if the sound produced by the operator at the transmitting end does not vary much, the contact may be prolonged. The remedy for this defect is in substituting for the voice of the operator a tuning fork, arranged to vibrate, for example, by a battery [*muni d'un système trembleur*]; then a note would be produced which would be better defined, but always very feeble. As to improvements which would be of a nature to render this telegraphic apparatus practicable, Mr. Koenig is well fitted to find them. We already know certainly that the intensity of the sound increases as a softer iron is used, because in that case the molecules have more freedom of motion than they had in the hardened iron or in steel. If the iron core is magnetized by the influence of a permanent magnet, or by another coil, its sound is more intense when the intermittent current is sent in such a direction as to produce a demagnetizing effect upon it, and it is less intense when the current is sent through the helix in such a direction as to increase the magnetism. The reason is, that in this last case the molecules are in advance, in a position already very near that which the current can compel them to take. Too much tension in the core also makes the sound more feeble, for the molecules having been already placed in a forced position, are less free to receive further motion. The electrical transmission of musical sounds is therefore a problem of which the true solution has not yet been found; and all the magnificent promises which have been made and published on the subject of acoustic telegraphy seem to us still to belong to the region of illusions.

ERNEST SAINT-EDME.

1925

No. 37. — PORTEFEUILLE ECONOMIQUE DES MACHINES, Paris, 1864, Vol. IX., p. 101, *Telegraphic Review.*

Ries' Acoustic Telegraph.

In the February number, 1864, of the "Nouvelles Annales de la Construction," we have mentioned a new system of telegraphy which aimed at nothing less than to transmit sounds with the greatest purity.

Since that time, frequent reference was made to this discovery. We are also desirous to inform our readers precisely upon this question in describing to them the telephone of Mr. Ries, and in presenting the results of experiments which we have made in common with Mr. Koenig, upon an apparatus made under the control [*controlé*] of the inventor himself.

The phenomenon, observed by many physicists, will be remembered. A bar of soft iron being placed within a helix commences to vibrate as soon as the wire is traversed by an electric current, and if, with the help of an interrupter, the passage of the current is broken, the succession of partial noises gives place to a sound, the pitch of which depends upon the number of interruptions produced at the time. Based upon this fact, Mr. Ries has constructed his telephone, or acoustic telegraph.

The transmitter [*manipulateur*] is represented by a hollow, rectangular box; one of the lateral faces is furnished with a mouthpiece intended to receive the note for transmission; the top is a membrane suitably stretched, at the centre of which is fixed a strip of platinum, which is placed in communication with one of the poles of the battery; above this is placed a second movable strip which, when at rest, presses upon the other by a fine point, also of platinum. It will be seen that if the membrane vibrates, it will toss the movable strip into the air, which will fall back again; now follow a number of oscillations, which exactly correspond to those of the membrane.

The receiver is composed merely of the magnetizing helix, within which is fitted a soft iron bar; the whole is mounted upon a resonant re-enforcing box. At the moment of operating, the two instruments are placed in the circuit of an ordinary line battery. The working of the apparatus is easy to understand; the vibrations

impressed upon the air enclosed within the box of the transmitter, by the operator placed before the mouthpiece, are repeated by the membrane; in consequence, the contact is made and broken successively between the two platinum strips; now follow a number of interruptions in the passage of the current through the receiving helix, which must be equal to the number of vibrations of the membrane of the transmitter. Now, since a single break produces but a simple jar, a series ought to produce a sound identical in pitch with that made at the mouthpiece of the receiver.

The telephone of Mr. Ries was an admirable instrument if it fulfilled completely the anticipations of the theory. Without prejudging the future, it must be admitted that it is not so as yet. When the musical scale is produced at the transmitter, it requires a well-trained ear to recognize the sounds which the receiver repeats amidst the tremblings which agitate it. Moreover, the model of which we speak is exposed to numerous sources of error; the membrane cannot, at certain moments, vibrate with the same amplitude, thus causing at times omissions of contact. If the sound is uttered close to the transmitter, the contact will be prolonged. This defect may be cured by substituting for the voice of the transmitting operator a tuning-fork, provided with a rheotome; the note is then much clearer, yet always very feeble.

Thus, the electric transmission of musical sounds is a problem of which the true solution has not as yet been found, and the promises which have been published on account of the acoustic telegraph are yet to be realized.

ERNEST SAINT-EDME,
Preparateur de Physique
Au Conservatoire des Arts et Métiers.

No. 38. — AMTLICHER BERICHT UBER DIE NEUN UND DREISSIGSTE VERSAMMLUNG DEUTSCHER NATURFORSCHER UND ÄRZTE IN GEISSEN IM SEPTEMBER, 1864, p. 84.

[Official Report of the Thirty-ninth Conference of German Naturalists and Physicians, at Giessen, in September, 1864.]

"Afternoon sitting, 21st September, 1864. Prof. Buff speaks about the tones of iron and steel rods when magnetized, and exhibits the corresponding experiments.

"Dr. Reis demonstrates his telephone, gives thereupon an explanation and the history of this instrument.

"Prof. Poggendorff produces tones in a metal cylinder, the slit-up edges of which touch one another firmly, and which is placed loosely round an induction bobbin through which there goes an interrupted current."

[The foregoing is the translation given in S. P. Thompson's book, p. 94, and there entitled "Extract from the Report of the German Naturalists' Society, held at Giessen (1864)."]

No. 39. — PROCEEDINGS OF THE LITERARY AND PHILOSOPHICAL SOCIETY OF MANCHESTER. Published at Manchester, 1865.

PHYSICAL AND MATHEMATICAL SECTION.

NOVEMBER 10, 1864.

Joseph Baxendell, F. R. A. S., president of the section, in the chair.

Professor Clifton exhibited an acoustical electric telegraph by which a note, sounded at one end of the line, is reproduced at the other end.

He also pointed out the principles involved in the construction of this telegraph, viz. : —

First. The production of a sound whenever a current of sufficient strength commences to circulate around an electro-magnet, or ceases so to circulate.

Second. The vibration of a stretched membrane in accordance with a note sounded near it.

With respect to the second principle, Professor Clifton drew attention to the fact that the researches of MM. Bourget and Bernard, in agreement with the mathematical investigations of Poisson and M. Lamé, show that a given square membrane will *not* vibrate in accord with *any note*, as stated by Savart. As the same is probably true of circular membranes, such as that used in this telegraph, it follows that only certain notes are capable of being transmitted by one instrument.

1936

No. 40. — ANNALEN DER CHEMIE UND PHARMACIE, Leipzig, 1864–1865, III., Supplementband, p. 134.

[Foot-note of an article by H. Buff, entitled "On the Tones generated in Iron Rods by the Electric Current."]

ARTICLE ITSELF COMMENCES ON P. 129.

[*Translation.*]

"This tone, appearing only as a secondary phenomenon, has been utilized with success by Dr. Reis of Friedrichsdorf in the instrument which he invented and named 'the telephone,' for transmitting tones telegraphically by means of the periodic impact of the sound waves of the same against an elastic skin.

"The arrangement is such that the skin, which vibrates in equal periods with a source of sound acting upon it, serves as a means for interrupting the electric current, which, at a distance, circulates around an iron wire, the ends of which are clamped upon a resonating plate.

"Unfortunately, by this otherwise ingenious arrangement, the pitch only of musical tones within several octaves, but not the quality [Wohllaut] of the same, could so far be transmitted through wire circuits."

No. 41. — KOENIG'S "CATALOGUE DES APPAREILS D'ACOUSTIQUE," Paris, 1865, p. 5.

29. TELEPHONE OF M. REIS. 60 FR.

This apparatus is intended to transmit sounds to a distance by means of electricity. It rests upon the fact demonstrated by the preceding apparatus. [*The preceding apparatus was the Wertheim coil and core, which Reis uses for a receiver.*]

At the first station the current traverses a little band of platinum which is attached to a membrane in such a way as to follow all its movements, and of a very movable point, which rests lightly upon this membrane. At the other station the current traverses a coil, at the centre of which is a bar of soft iron. If now we produce before the membrane a sound which causes it to vibrate, each vibration in pushing away the point from the platinum plate will produce an interruption of the current. On the other hand, each making of the current will produce in the bar of soft iron at the second station a momentary and weak sound. It is the rapid and isochronous suc-

cession of these sounds, all acting as simple blows, which produces the continuous sounds that are heard. It is true that they are not of good quality and that they cease from time to time. This comes from the fact that the membrane does not vibrate equally well for all tones, and because the manner in which the vibrations determine the interruption of the current, by pushing the little point away from the plate, is far from being perfect.

No. 42. — PISKO, DIE NEUEREN APPARATE DER AKUSTIK, Wien, 1865, pp. 94 *et seq.*

[Page 94.] 51. (*a.*) *Principle of the Telephone of Reis.* The "Telephone" of Reis (Fig. 60) is related to the Membrane-Phonautograph. The round end *s* of a light strip of platinum *n s* is fastened upon the membrane *m m* with wax in such a way that the strip of platinum can make all of the vibrations of the membrane with it. Very near to this end *s* of the strip of platinum *n s* is a platina point fixed so that it is touched by the strip of platinum as this vibrates with the membrane. If we suppose the outer end *n* of the platina strip *n s* and the platina point to be connected with the poles of a battery, then a current is established or broken by the vibration of the membrane, according to its phases. An electro-magnetic bell or an electro-magnetic telegraph introduced in this circuit would transmit to a distance indications that some one was speaking, but they would, self-evidently, not be able to make known what was spoken.

(*b.*) It is well known that an iron wire, surrounded by strong galvanic currents frequently broken, is made to sound forth tones which may be longitudinal or transverse, or both at the same time. Reis introduced such an iron wire lying in a multiplying coil at the second station C. This produced tones, if the membrane was caused to vibrate by singing or talking into (S, Fig. 60) the hollow, cubical part A. In my experiments with the telephone the rod never changed its pitch even with the most different tones and sounds [Töne und Klänge] and always produced only the rhythm of the words sung or spoken at S into the part A. The aria of the song sung into the instrument could generally be recognized from the rhythm. The experiments, with special reference to this, are recited

1928

in § 53. But this much is evident already, that time must yet elapse before the simultaneous concerts and singing productions so ardently hoped for by the newspapers. The apparatus of Reis is indeed a "Telephone," but not a "Phonic Telegraph." The only means of transmitting song and speech, and this only for moderate distances, is the old well-known speaking tube. But the experiment of Reis can always be classed with the most beautiful and interesting of school experiments; and as the means for producing it are simple, the apparatus of Reis will surely soon find its way even into moderately endowed institutions. That the sounding of the wire in the telephone is not due to acoustic transmission can be shown by cutting the coil out of the circuit; the sounding ceases at once.

"1. Reis's phonautograph was originally made of a wooden cube with a conical cavity. The smaller opening was covered with the membrane. A knitting needle was used as the sounding wire, which projected about two inches out of each side of the multiplying coil, and rested upon two bridges of a resonance box. The surrounding [page 96] coil consisted of six layers of fine wire. Fig. 60 shows the telephone as it is at present manufactured, according to the inventor's directions, by mechanician Albert, in Frankfurt, and mechanician Hauck, in Vienna.

"2. Even though the telephone cannot be used to reproduce concerts, this can be accomplished for moderate distances by the resonance of solid bodies, in narrow limits, to be sure. Pepper, director of the Polytechnic Institute, formed at London for amusing sciences, gave such a concert (1855) with Wheatstone's method. Four of Erard's harps stood upon the stage. Each had on its resonance board a short staff of pine 2 cm. thick.

"By turning the harps on their axes this staff was made to touch an exactly similar one, which extended into a deep cellar, and there was in contact respectively with the sounding board of a piano, of a violoncello, of a violin, and the mouthpiece of a clarinet.

"As long as the resonance staffs touched, the concert was heard distinctly; but as soon as one or all the harps came out of contact with the sound-conducting staff, the music ceased. The character of the instruments played was, as a whole, preserved, only the violoncello tones being somewhat raspy."

52. *Particulars regarding the Telephone.*

(*a.*) It consists substantially of (Fig. 60).

1. The transmitter A.
2. The receiver C.
3. The battery B, and finally of
4. The connecting conducting wires

(*b*.) The transmitter A is essentially a parallelepipedic body of wood. Its upper part *u x* is cut out of one piece of square section, the side *z x* measuring 9 cm., its height *u x* 2.8 cm.

This part can be moved on the lower box A A by means of hinges. If we turn back the cover *x u* we shall notice a small circle cut out in it 3.9 cm. in diameter. A brass ring, with a margin 8 mm. broad, fits into this hole, which is furnished with a groove like a pulley.

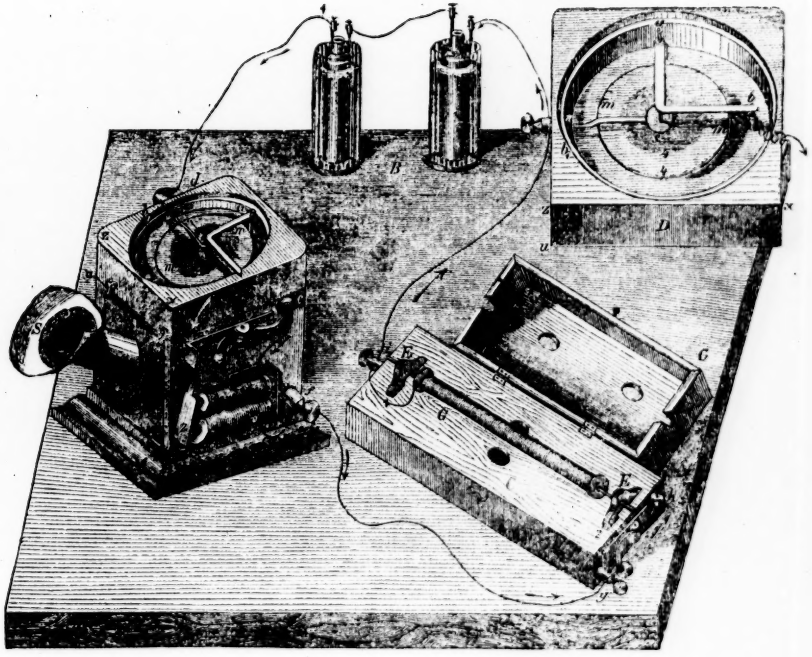
Over the ring the membrane *m m* is stretched by a silk thread lying in the groove of the same. This circular membrane is surrounded by a wider circular hollow *b* $b_1 = 8.5$ cm. A shovel-shaped strip of platinum *n s* is placed in connection with the brass binding post *d*, and rests by its circular piece *s* on the centre of the membrane.

By means of sealing wax this circular part is fastened to the membrane, and is thereby compelled to accompany the membrane in its vibration. The farther transmission of the galvanic current from the centre of the membrane takes place by means of the brass angle *a s b* (D, Fig. 60). This rests at *s*, by means of a platinum or steel point, upon the conducting platinum strip *n s*, and dips at *b* with a platinum or steel point in a mercury cup which is made in a screw transmitting the current [die den Strom weiter leitet]. The point *a* serves only as a base or support for the angular piece *a s b*, which in general is supported like a tripod, in order that the contact point *s* should remain as constant as possible. The angle *a s b* is simply pushed over a projecting pin by a hole at *a*, until it remains resting on a broader lower part. From *b*, the electrical conductor with a covered wire extends to the brass key *e* (A, Fig. 60) by a spiral wire, and from there further in the direction indicated by the arrows.

The under part A A of the transmitter is constructed of wooden boards and form a parallelepipedon whose height = 6.8 cm., and whose breadth = 7.7 cm. For the reception of tones there is the slanting attachment S made of tin with a funnel-shaped enlargement.

The longer side of this attachment is 6.7 cm., the shorter 4.7 cm.; the vertical diameter of the enlargement measures 7.15 cm., the horizontal diameter 7.5 cm., and finally the diameter of the narrower cylinder 3.9 cm.

1930



It is plain that, if necessary, the platinum strip can be replaced by a thin strip of brass, and the platinum or steel points by iron ones. Only then the contact points must oftener be cleaned to a metal polish.

(*c.*) The receiver is in general a double resonance box, whose upper part, "the cover," is movable on two hinges and can be laid back. The length of this cover is 16.4 cm., its width 9.5 cm., and its height 3.2 cm. The length of the under box measures 22.9 cm., its width 9.6 cm., and its height 2.5 cm. The under part of the resonance box has two wooden bridges, which are separated from each other 7.4 cm., and serve as supports for the iron needle, which is 21.5 cm. long and 0.9 mm. thick, and intended to produce the tones. The length of the spiral placed over the needle and designed for producing the electro-magnetism is 15 cm. The wooden covers of both parts must be constructed as thin as possible, and the greatest breadth of the circular holes seen in the figure measures 13 mm.

(*d.*) One can successfully use as battery a small four-cell Smee's or two larger Bunsen's cells. The conducting line must be made at least so long that the exciting tones can no longer be heard [through the air]. For corresponding between the two stations, the inventor has arranged the electro-magnetic telegraphic apparatus *e v g h*, easily seen and understood from the figure. Agreement can be easily had as to the corresponding signals, and it is simplest to accept the sign suggested by the inventor. (26.)

The receiver C gives, on tapping with the key *e*, the corresponding signals by the rod E E giving out tones, while at the transmitter A the electro-magnet *v* announces the signals by means of the spring armature *z*.

53. *Experiments with the Telephone.*

(*a.*) As soon as one brings his mouth to the funnel S, and sings, the membrane of the transmitter A falls into corresponding vibrations, and the little iron rod *e e* at the second station begins to give out tones. Every time that a spark is visible at the first station, at *s*, the rod certainly sounds at the other station. The same is true when the peculiar buzzing tone is perceived, which arises from the striking of the vibrating platinam strip upon the point of the angular hook resting thereupon. The appearance of these sparks, or of the peculiar buzzing at the transmitter A, announces to the observ-

ers at the station A that the rod at C is giving forth tones. Tones and melodies, which were sung into the sound opening S, and especially clangs in which the teeth and head-bones also vibrate (the so-called humming tones), always produce a toning of the rod or needle E E, and indeed, as already mentioned (§ 51), without change of pitch, only with the reproduction of the rhythm of the respective song or words.

The pitch of the tone excited at C in the rod E E was, in the apparatus at my disposal, h', its strength not very remarkable and its quality [Klang] buzzing like that of the tone of a weak-sounding reed-pipe (something like a child's trumpet). The skin lying about the pericardium of the smaller and even the larger mammals (calves, etc.) makes the best membrane,—gold-beater's skin reproduces only the lower tones.

The cover of the resonant box seemed superfluous in my apparatus, and the tone was indeed somewhat stronger without the cover.

1. In experiments with the telephone, close attention must be paid to seeing if the end *s* of the platinum strip still sticks to the membrane, and, if necessary, it must be pressed upon the membrane. When this leaf will no longer cling, a knife blade is heated, a piece of sealing wax touched with it, and the melted wax thus transferred to the under side of the round end of the platinum strip *n s*. Immediately thereupon it is pressed on to the membrane *m m*.

2. From a long line of experiments, which I have performed with the telephone, I take the liberty of giving here some results: —

(*a.*) A Cagniard-Latour siren with upright axis, blown near the opening S from the lowest to the highest tone gave no result Only when the rotating plate was turned directly toward the funnel-shaped sound receiver S, and brought very near the same, was it twice possible with the medium tones of the siren to hear two short tones of the iron rod *e e* of the pitch h^1.

(*b.*) A tuning-fork with normal tone a^1 aroused no tone whatever in the receiver C, neither when in immediate vicinity of the sound funnel S, nor when laid upon it.

(*c.*) A metal bell, which gave, according as it was rubbed with a strong bow, the tone h^1 or dis^2=d^{-3}sharp, produced no results from the telephone, even when the bell was brought ever so near to the sound reed S, or when laid upon it. Only when the tone h^1, by means of suitable resonant tubes was very perceptibly strengthened, did the telephone respond weakly and shortly, and indeed again with h^1.

(*d.*) Wooden lip pipes belonging to the scale between c^1 and c^2, when laid with the walls of their reeds on the sound funnel S and made to give out tones, were not able to bring the telephone to produce tones, but they were most

active in respect to the telephone when the under open end of the reeds was brought immediately before or into the opening S of the sound cylinder of the transmitter A; this position may be called the "first."

These pipes also worked successfully upon the telephone, when their mouths (the holes) were laid on* the sound-conducting opening S. This position may, from now on, be called the "second." If the pipes in both positions were removed only a few lines from the sound receiver S, the effective vibration of the membrane ceased, and, in fact, in the first position sooner than in the second. If, however, pipes of any material of different length (1 ft. to over 8 ft.) and different widths were laid on the conducting sound tube, and the former pipes applied to these in the first or second position, the telephone gave the same results as in the immediate use of the short transmitting tube.

(*e.*) The former pipes, when covered,† caused (as was to be foreseen) the telephone mostly not to sound at all, or only interruptedly in the first position. In the second position, the telephone was excited by them for the most part completely, seldom interruptedly.

(*f.*) I had at my disposal no pipes of the c^3 scale. Tones from the latter scale, which by strong blowing were excited in the pipes used by me, gave mostly no result, no matter what position was given to the pipe.

(*g.*) A reed-pipe of tone d^1 with open reed [mit aufschlagender Zunge]‡ excited the rod of the telephone only when its open end was turned toward and brought near the sound-receiving funnel S of the transmitter. Increasing the tone by a resonant tube produced an interrupted tone. A like result was obtained with a reed-pipe of the tone c^{-1} with full beat reed, only here the excited telephone tone was constantly interrupted.

(*h.*) The miniature-normal-diapason, a small reed-pipe of the tone a^1 (compare Chap. VI.), sunk into the sound-conducting reeds, so that the mouth lay on the funnel, produced a clear tone in the telephone when strongly blown.

(*i.*) Marches drummed at A with the key *e e* were produced by the receiver C, and in fact, always with the tone h^1.

(*k.*) Singing of different melodies was always successful; the rhythm of speaking was only interruptedly reproduced.

(*l.*) Whistling with the mouth into S had no effect, and the tone passed over into a higher one, probably because the vibrating column of air thereby became shorter. The tones f^1, g^1, a^1, fis^1, c^1 and cis^1, produced with the mouth by whistling passed over into fis^1, gis^1, b^1, g^1, cis^1 and d^1 respectively, as soon as the mouth lay immediately before the sound receptor S.

There was a rise in tone of half a tone. Similar rise in tones is obtained by whistling into a cup, hat, etc. Indeed, the cutting off of the current of air coming from the mouth by the flat of the hand raises the tone in such whistling, and this can be very easily recognized by moving the hand up and down.

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* Should probably be, *placed before;* the original is obscure, viz., "an die schallzuleitende Öffnung S legte."

† The German word is "gedeckt," but it is used in the technical sense, *i. e.*, closed at their ends.

‡ A reed which, at each vibration, closes the air passage completely; the instrument is now obsolete.

(*m.*) Since the distinct buzzing of the platinum strip on the transmitter S is a sure sign that the iron rod (E E) is sounding at C, there is no need in this respect of telegraphic communication between the stations (§ 52, d).

(*b.*) If a comparison is made of the results of experiments with the telephone and those with the membrane-phonautograph, it will seem at first as if the latter did much too little in comparison with the former. This contradiction, however, rapidly disappears. The membrane-phonautograph also gives plain tone writings of a melody in the space of an octave, together with double tones and chords, and according to Donders, still more. Moreover, in the telephone the membrane is moved not only by the vibrations of that tone, by which, according to the laws of sympathetic vibration, it can be brought into vibration, but it is also mechanically raised and lowered by the strong condensations and rarefactions arising from the exciting tone (singing, etc.) in the enclosed masses of air. Every condensation will press the membrane outward, even when its deepest normal tone is much higher than the exciting (sung) tone. Very strong and thick membranes might perhaps resist this purely mechanical excitation, but they would be then not sensitive enough for real sympathetic vibration. In many cases (for example, in drumming with the key on the box, in placing the apparatus A on the resonant cover of a piano, etc.), the vibration of the membrane in the telephone arises also only in the same way as the membrane in König's pipes for proving the nodes of vibration (compare a later paragraph). In this, also, the stretching of the membrane is not necessary in order that the latter may show outwardly the condensations and rarefactions of the air in the pipe.

Pipes with thin walls furnish a further proof of this. The latter allow trembling to be felt when touched by the hand while the pipes are sounding; indeed, very thin walls deepen the tone somewhat, and thereby show that they are not able to resist the pressure arising from the condensations.

Sand sprinkled upon walls of this kind is thrown off from the nodal points. If, therefore, thin strips of wood are able to imitate in such a manner the vibrations of the air in the pipe, although the proper tone of the wall may lie far from the exciting tone, this is certainly much more the case with a membrane. The experiments

with the pipes cited in the previous paragraph also confirm this, for they only then gave a result in the telephone when the open end or mouth of the pipes lay very near the sound receptor, and even the experiments with singing confirmed this view. Just these experiments show the telephone weaker in comparison with the membrane-phonautograph, because in the latter, when the membrane is tuned for a tone, the tone-writing comes, whatever position the exciting tone may have in reference to the sound-receiving side of the membrane-phonautograph, provided only it is near enough. And yet it would seem that to close the battery by means of the vibrating platinum strip on the membrane demands less strength than to move the little pen so that it may be able to remove the lampblack on the writing cylinder. The results of the few experiments with the telephone appear moreover to indicate that it might, perhaps, be more advantageous for the production of tone-writing by means of the membrane-phonautograph, to make the latter of smaller dimensions than has been the case up to the present. In fact, König is already busy on new arrangements for the membrane-phonautograph. König already hopes a better result for the written reproduction of simple sung melodies, if the wide opening of the paraboloid in the membrane-phonautograph be closed by a plate which had a small opening for applying the mouth.

In any case, a renewed study of the laws of the sympathetic vibrations of the membrane with especial reference to both pieces of apparatus will be necessary. Many think that the membranes must vibrate sympathetically to every tone, because all the tones are heard by means of the membrane in the ear, but in this respect it is very important to note that, according to Prof. Mach (27), this may be brought about by a proper accommodation-mechanism in the ear. For me this supposition of an accommodation, producing varying tensions of the tympanum, has a high degree of probability bordering on certanity.

Ph. Reis showed his apparatus for the first time in October, 1861, in a very primitive form to the Physical Society at Frankfort-on-the-Main; on July 4th, 1863, to the same society he showed the form represented in Fig. 60. This time he experimented over a distance of 300 ft. Prof. Böttger introduced the apparatus to the Naturforscher-Versammlung, at Stettin (1863), in the Physical Section.

No. 43. — PISKO, DIE NEUEREN APPARATE DER AKUSTIK, Wien, 1865, p. 241.

[REIS PROSPECTUS.]

26. Here may be the place for the prospectus which the inventor, Mr. Ph. Reis, attaches to the apparatus furnished by him and made by the mechanician, Mr. Albert, in Frankfurt.

"*Telephon.*" Every apparatus consists, as can be seen from Fig. 60, page 96, of two parts, the telephone proper and the receiver C. These two parts are placed at such a distance from each other that singing, or toning of a musical instrument, can be heard in no other way from one station to the other except through the apparatus.

Both parts are connected with each other and with the battery B like common telegraphs. The battery must be sufficient to bring about at station A the attraction of the armature in the electro-magnet fastened at the side (3-4 six-inch Bunsen cells are sufficient for several hundred feet distance).

The galvanic current goes from B to the post *d*, from here through the copper strip to the platinum-leaf on the middle of the membrane, then through the foot (at D, Fig. 60) of the angle to the screw *b*, *in a small cavity of which a small drop of mercury is placed.* From here the current goes through the small telegraph-apparatus *e–f*, then back to the key of the station C and through the spiral over *i* back to B.

If now sufficiently strong tones are produced in front of the sound-opening S, then through the vibrations of the same, the membrane and the angular-shaped little hammer lying upon it are set in vibration; the circuit is alternately opened and closed at every full vibration, and hereby are produced in the iron rod of the spiral at station C the same number of vibrations, and these are perceived there as tone or tone-combination (Accord). By laying the upper box tightly upon the axis of the spiral, the tones at C are very much strengthened.

Besides the human voice there can be reproduced (according to my experience) just as well the tones of good organ-pipes from F — c and those of the piano. For the latter purpose A is placed upon

the sounding board of the piano. (Of thirteen common chords an experienced experimenter could clearly recognize 10.) As regards the telegraphic apparatus attached to the side, this is clearly unnecessary for the reproduction of tones, but it forms a very agreeable addition for comfortable experimenting. By this it is possible to correspond right well and surely with one's vis-à-vis.

This takes place somewhat in the following simple manner: —

After the apparatus is completely set up, assurance is had of the continuity of the conductor and the strength of the battery by opening and closing the circuit, when at A the striking of the armature and at C a very perceptible ticking of the spiral is heard.

By quickly alternately opening and closing at A it is asked at C if they are ready for experimenting, whereupon C answers in the same manner.

Simple signals can by agreement at both stations be given by opening and closing the circuit once, twice, three times, or four times for example: —

1 stroke = sing,

2 strokes = speak, etc.

I telegraphed words by numbering the letters of the alphabet and then communicating their numbers: —

1 stroke = a,

2 strokes = b,

3 strokes = c,

4 strokes = d,

5 strokes = e, etc.

z would in this way be designated by 25 strokes.

This number of strokes would, however, waste time in representing and would be difficult to count surely, wherefore I place a dactyl stroke for every five strokes, then we have,

—00 for e,

—00 and 1 stroke for f, &c.

z= —00 —00 —00 —00 —00, which is more quickly and easily carried out, and better to understand.

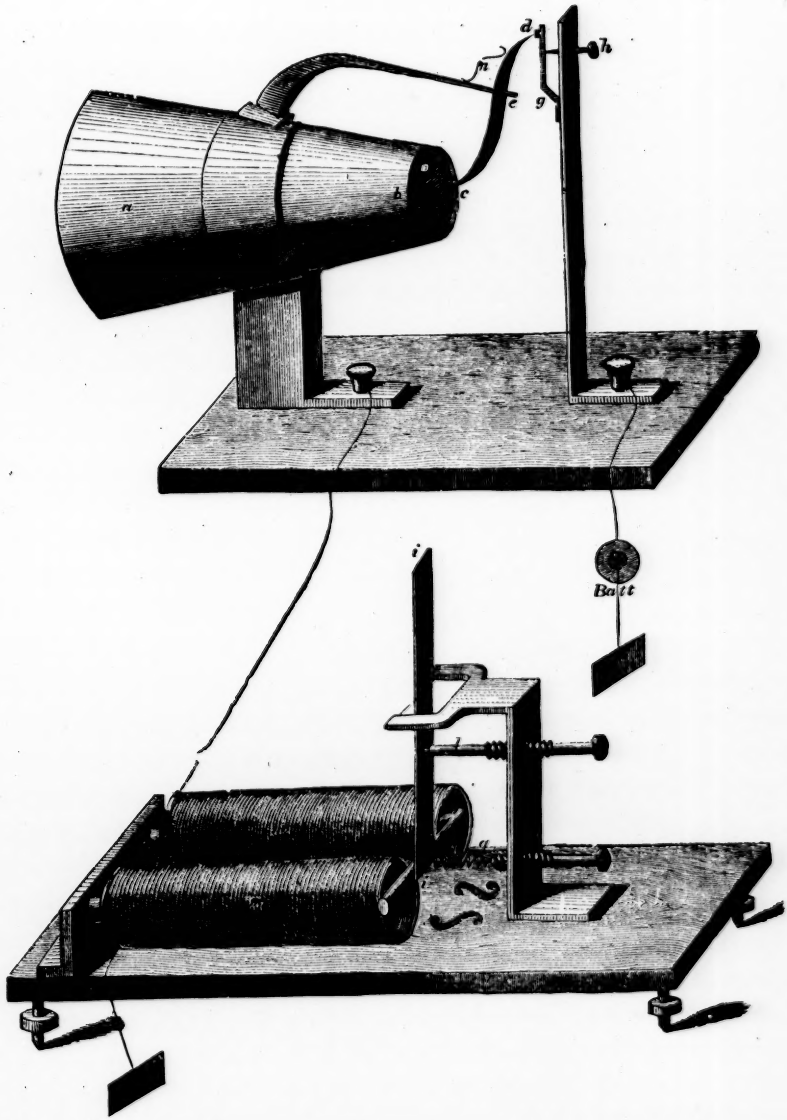
It is still better to designate the letters by numbers which are inversely proportional to the frequency of their recurrence.

No. 44. — HANDBUCH DER ANGEWANDTEN ELEKTRICITATSLEHRE, Von Karl Kuhn, 1865, pp. 1017–21.

[Manual of applied Electricity.]

The experiments made by Reis in Frankfurt-a-M., on the 26th October, 1861, have proved, however, that when the breaks of the current [Stromunterbrechungen] follow each other almost continuously and very quickly in a coil provided with a thin iron core, the iron wire can enter into longitudinal vibrations, and in this way be enabled to reproduce sounds of different pitch. An exact reproduction of the sounds does not take place, however, but only an imitation; for this reason it cannot be questioned here of transverse vibrations [transversal Schwingungen]. A phenomenon [Erscheinung] has otherwise been heard of, which belongs to the afore-mentioned class, in which the intensity and the timbre [Klang] of the sound accompanying it (the phenomenon) depend among other things on the strength of the current [Strom stärke] and on the number of breaks of the same, and in which, as it seems, the pitch of the tones also can vary under different circumstances. We can, however, hardly imagine by what arrangements it could be feasible to coax tones of any given height or depth out of an iron or metal tube split on one side, while it (the tube) is affected by the alternate currents of an induction apparatus the coil (Rolle) of which surrounds it. Yet the possibility cannot be controverted that the principle of Neef's circuit-breaker (Unterbrecher) might contribute to the solution of the problem in question. It has been employed for local purposes either with or without modifications in the study and investigation of acoustic phenomena. Thus Petrina has used the principle of Neef's circuit-breaker [Unterbrecher] for his electric harmonica in this way, that instead of the Neef hammer a little rod was chosen, the transverse vibrations of which rendered the tone. "There are four little rods of various lengths side by side, the motions of which are checked by means of levers managed by finger keys." That principle was used previously by Dove, in a modified manner, to set strained strings and elastic springs into acoustic vibrations of constant amplitude by means of an electric magnet, and, in this way, to be enabled to investigate constant tones. It appears

1939



from Legat's published communications that "the ideas submitted by Ph. Reis of Friedrichsdorf in the Physical Society and in the meetings of the German Hochstift in Frankfurt-a-M. about the reproduction of sounds by means of electricity" referred to arrangements of a similar kind. Legat mentions in his paper all that has been done thus far towards the realization of that project, and we borrow from it that part only which throws some light on the construction of a telegraphic apparatus with which it is said to be possible to produce vibrations and make sounds in any desired manner and through which the employment of electricity is said to make it feasible to bring forth at any given distance vibrations similar to the first produced ones and in this way to reproduce at a certain place tones originally produced at another place.

This apparatus is composed of a transmitter and of a receiver. The transmitter (Fig. 504, p. 1019) consists in a conical tube *a b* about 15 cm. long, 10 cm. at the front, 4 cm. at the back opening; the choice of the material as well as a greater length is indifferent; a greater width, on the contrary, is disadvantageous; the surface of the interior must be as smooth as possible. The narrower back opening is closed by a membrane of collodion *o*, and on the middle of the circular surface formed by this membrane rests one end *c* of lever *c d*, the fulcrum of which is held by a support and remains connected with the metallic circuit. This lever, one arm *c e* of which must be considerably longer than *e d*, should be as light as possible so as to follow easily the motions of the membrane, as an uncertain obedience [folgen] on part of lever *c d* would produce imperfect tones at the receiving station. In the state of rest, the contact *d g* is shut and a weak spring *n* holds the lever fast at rest. On the metallic support *f* which is connected with one of the poles of the battery is a spring *g*, with a contact which touches the contact of lever *c d* at *d* and the position of which is regulated by screw *h*; over tube *a b* a disk must be placed which encircles the outer circumference of the tube closely, so that the efficacy of the apparatus may not be impaired through the effect of the air waves coming round and striking against the rear end. This disk at right angles with longitudinal axis of the tube measures about fifty (?) cm. in diameter. The receiver (Fig. 505) consists of an electro-magnet

1941

m m which rests on a sounding board, and the coil of which is in connection with the metallic conductors, and with the ground. Opposite the electro-magnet is an armature connected with a lever as long as possible, but light and broad, which latter, with the armature, is fastened pendulum-like on the support *k*. Its motions are regulated through screw *l* or spring *o*. "In order to increase the efficacy of the apparatus, this receiver can be placed in one focus of an ellipsoidal enclosing box of suitable size, while the ear of the hearer is placed at the other focus." The working of the two apparatus (the mode of connection of which is visible in the woodcuts), the transmitter being placed at one station and the receiver at the other, is as follows: By speaking, singing, or the intromission of instrumental sounds into tube *a b*, in consequence of the condensation and rarefaction of the column of air, a motion of the membrane *c* corresponding to these changes is brought about. Lever *c d* follows the motions of the membrane, and opens or closes the circuit, according as a condensation or a rarefaction of the air inside takes place. As a consequence the electro-magnet *m m* (Fig. 505) is correspondingly demagnetized or magnetized, and the armature affixed to it (as well as the armature lever) is set into similar vibrations as the membrane of the transmitter. Through lever *i* connected with the armature, similar vibrations are communicated to the surrounding air and (the increasing effect of the sounding board helping) the tones so produced finally reach the ear of the listener. In respect to the operations of this apparatus, the author remarks that the receiver does reproduce the exact number of the original vibrations, but that a reproduction of the original intensity has not yet been attained. For that reason, it is added, small differences in the vibrations are appreciated with difficulty, and in the practical experiments made thus far, it was possible to transmit with astonishing faithfulness chords, airs, etc., whilst in reading, speaking, etc., single words were more indistinctly heard. The apparatus just described is said to have been one of the constructions which Reis has used himself in his experiments. The underlying principles might give hopes of a farther improvement of the apparatus, but the telephone which, according to later reports, Reis has finally decided upon, has the disposition represented in

Fig. 506, although the principle on which it is founded does not stand quite in harmony with the above-mentioned investigations of Wertheim, for instance.

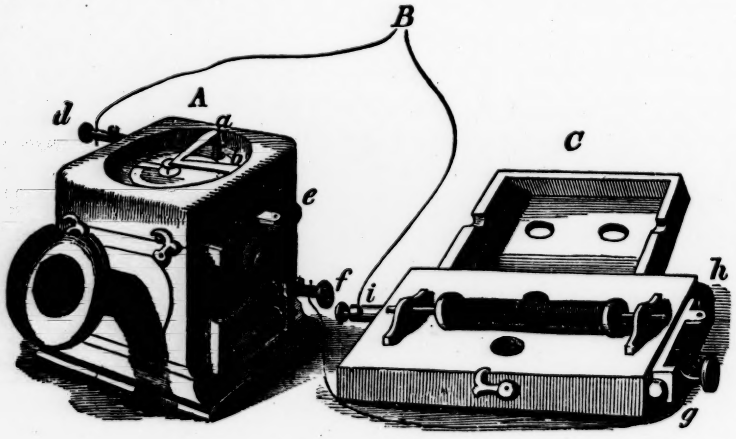


FIG. 506.

The telephone proper A consists of a hollow wooden box provided with a short sound-funnel S and the upper side of which is open in the centre and covered over tightly with a delicate membrane. On the middle of the latter a thin platinum disk is fastened, from which on one side a platinum strip establishes circuit connection with the contact of the key at *e*, from which place the metallic connection is effected with one end of the coil of a small electro-magnet provided with a spring armature, whilst the other end is in contact with screw *f*. The reproducing apparatus C set up at the receiving station consists simply of a coil about six inches long formed by winding six layers of copper wire; in the axis of the coil a thin iron wire ten inches long (a knitting needle), protruding out of each end of the coil about two inches, is so disposed that with its bridge-like supports it rests on a sounding board. By means of screw *i* and of the key at *h g* the coil is thrown into the circuit and the connection of both apparatus is effected in the manner mentioned; a battery being placed at B, the course of the current is easily followed out. It can flow from B through *d c* and *c b* to *e* and *f*, and from here to the receiving station, and at *i* return to the battery, or it can start in

the opposite direction according as *d* or *i* forms the starting point of the current. The circuit can be broken at will at each of the two stations by pressing the key lever, and a connection can be established thus in either direction, but the discontinuous currents which are to produce the sounding of the iron wire at C are obtained in this way: By singing or the blowing of instruments towards the sound-funnel S the membrane at A is made to vibrate; if this can be brought about, it will happen, as was demonstrated by the experiments, that the iron wire of the receiver assumes isochronal vibrations, and whenever this is the case, it reproduces the same tones which set the membrane to vibrating at the transmitting stations.

My own experiments have demonstrated that every melody starting from *c* and embracing the entire extent of an average male voice, when sung into the telephone, can be reproduced by the receiver at C. The timbre [Klang] or quality of the sounds thus reproduced is not pleasant, — they are almost like the sounds of toy trumpets, at times also like the buzz of a fly caught in a spider's web and the like; yet the experiments of Reis are certainly interesting enough to challenge attention.

A reproduction of the words spoken into the telephone with or without variation of pitch was audible at the receiver only in a corresponding noise [entsprechendes Geräusch], while a discriminate perception of single vocal sounds, syllable or words could not be had. According to communications made on this subject by Reis, he has succeeded in reproducing the tones of organ pipes not covered, and those of a piano; in this latter case the transmitter was placed on the sounding board of the piano.

No. 45. — LEHRBUCH DER TECHNISCHEN PHYSIK, Hessler, Wien, Vol. I., p. 648.

[Hessler's Text-book of Technical Physics, Vienna, 1866, Vol. I., p. 648.]

The subject of phonotelegraphy will end this chapter on telegraphy. This rests upon a phenomenon first observed by Page, afterwards confirmed by Mariani, and more exactly studied and

experimented upon by Wertheim; that is, that iron, under the influence of alternate magnetizing and demagnetizing by means of a galvanic helix, is set in longitudinal vibration and gives forth sound; and Reuss in Friedrichsdorf near Homburg showed beyond doubt the possibility of phonotelegraphy by means of an apparatus called by him telephone (Fig. 429), consisting of two parts, — the actual telephone (I), and the reproduction apparatus (II), used at the second station at a distance. Both parts are connected with one another and with a battery S as in ordinary telegraphs. The battery S must be strong enough to work the armature A of the electro-magnets E, E (three or four six-inch Bunsen's elements are sufficient for a distance of several hundred feet). The current passes from S to the binding screw 2, thence through the strip of copper *n* into the disk of platinum *o*, resting on the middle of a thin circular membrane (hog's gut), stretched across the upper end of the wooden box K, afterwards it goes through the foot (platinum point) *b* of the metallic angle *a*, *b*, *c* (this point standing on the disk *o*), into a vertical screw at *a* provided with a small cavity at its upper end containing a drop of mercury, into which there dips a platinum point descending from *a* while the angle *a*, *b*, *c* rests at *c* on a small metallic pillar, so as to be very easily made to vibrate about *a* and *c*. From this pillar (at *c*) the current goes through the key *t* and into the binding screw *i* connected with the wire leading to the pillar, thence through a wire stretched from this screw into the binding screw 3 on the apparatus II, then through the key *t* of this apparatus into the bobbin *g* (magnetizing coil), inclosing the iron or steel wire *d*, *d* of the thickness of a knitting needle, into the binding screw 4, and finally thence by wire back to the second pole of the battery S. If, now, we produce sufficiently strong tones by means of organ pipes in front of the opening of the tube T (or sing them through the tube T into the hollow box K), the sound waves will set the membrane *m* into regular vibrations. Every condensation occurring beneath *m*, at once raises the disk of platinum *o*, together with the platinum point *b* (the foot of the angle *a*, *b*, *c*), when the rarefaction occurs and *m* moves downward again, the angle *a*, *b*, *c* cannot immediately follow the disk *o*, and the current is interrupted, and a similar interruption

1945

occurs with every vibration of m, and in this way are produced just as many vibrations in the wire d, d of the coil g, at station II as the membrane makes; these vibrations are perceived there as tones or combinations of tones (accords). These tones are much strengthened by covering the coils with a box D of resonant wood, so placed as to fit the sounding board B, below. The keys t and t make it possible to communicate short messages as necessity arises, between stations I and II. (*E. g.*, to signify from II to I that they are ready to receive tones at II.) For by pressing down the keys the electromagnet E is included in the circuit, the armature A drawn up and made to strike upon E.

The telephone is yet in its infancy, it is true, but even now, by employing powerful currents, it transmits at a distance not only solitary tones, but even tunes consisting of slow consecutive tones, quite perceptibly and distinctly.

No. 46. — CATALOGUE OF J. WILH. ALBERT, MECHANICIAN AT FRANKFORT-ON-THE-MAIN, 1866.

Extract from Preface. "All instruments and apparatus will always be constructed according to the latest designs and improvements. In order that the construction may be better understood we have printed herein references where a description can be found as follows: —

"M–P. Müller-Pouillet's Lehrbuch der Physik, vi Auflage." [Other books also named.]

From body of Catalogue.

"839. Telephone of Reis for reproduction of tones by electricity, with description, 21 fl.

"M–P. Fig. 325–327. Pisco, Akustik, Fig. 60.

"840. The same in simpler design, fl. 14."

No. 47. — ELECTRICITY, by Robert M. Ferguson, William and Robert Chambers, London and Edinburgh, 1867, p. 257.

THE TELEPHONE. — This is an instrument for telegraphing notes of the same pitch. Any noise producing a single vibration of the

air, when repeated regularly a certain number of times in the second (not less than thirty-two), produces, as is well known, a musical sound. In Art. 115, we found that when a rod of iron was placed in a coil of insulated wire, and magnetized by a current being sent through the coil, it gave out a distinct tick when it was demagnetized by the stoppage of the current. A person when singing any note causes the air to vibrate so many times per second, the number varying with the pitch of the note he sings, the higher the note the greater being the number of vibrations. If we then, by any means, can get these vibrations to break a closed circuit in which the coil just mentioned is included, the note sung at one station can be reproduced, at least so far as pitch is concerned, at another. Reis's telephone (invented 1861) accomplishes this in the following way: —

A A (Fig. 141) is a hollow wooden box with two round holes in it, one on the top, the other in front. The hole at the top is closed by a piece of bladder S, tightly stretched on a circular frame; a mouthpiece M is attached to the front opening.

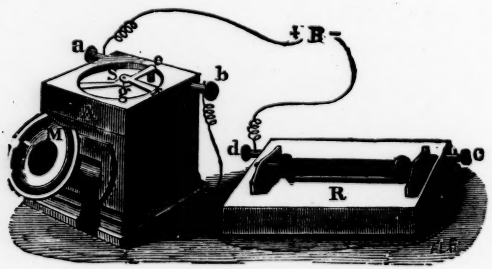


Fig. 141.

When a person sings in at the mouthpiece, the whole force of his voice is concentrated on the tight membrane, which in consequence vibrates with the voice. A thin strip of platinum is glued to the membrane, and concentrated with the binding screw *a*, in which a wire from the battery B is fixed A tripod *e f g* rests on the skin. The feet *e* and *f* lie in metal cups on the circular frame over which the skin is stretched. One of them *f* rests in a cup containing mercury, and is connected with the binding screw *b*. The third foot *g*, consisting of a platinum point, lies on the circular end of the strip of platinum just mentioned. This point, being placed on the centre

of the oscillating membrane, acts like a hopper, and hops up and down with it. It is easy to understand how, for every vibration of the membrane, the hopper will be thrown up for the instant from connection with its support, and how the close circuit is thus broken at every vibration. The receiving apparatus R consists of a coil of wire placed in circuit, enclosing an iron wire, both being fixed on a sounding box. The connections of the various parts of the circuit are easily learned from the figure. Suppose a person to sing a note at the mouthpiece which produces three hundred vibrations a second, the circuit is broken at the bladder three hundred times, and the iron wire ticking at this rate gives out a note of the same pitch. The note is weak, and in quality resembles the sound of a toy trumpet. Dr. Wright uses a receiving apparatus of the following kind: The line current is made to pass through the primary coil of a small induction coil. In the secondary circuit he places two sheets of paper, silvered on one side, back to back, so as to act as a condenser. Each current that comes from the sending apparatus produces a current in the secondary circuit which charges and discharges the condenser, each discharge being accompanied by a sound like the sharp tap of a small hammer. The musical notes are rendered by these electric discharges, and are loud enough to be heard in a large hall.

No. 48. — LEHRBUCH DER PHYSIK UND METEOROLOGIE. THEILWEISE NACH POUILLET'S LEHRBUCH DER PHYSIK SELBSTANDIG BEARBEITET. Von Joh. Müller. 7te. aufl. Braunschweig, Friedrich Vieweg und Sohn. 1868. (2 v.)

[Text-book of Physics and Meteorology. Partly according to Pouillet's Text-book of Physics, but independently arranged. By J. Müller. 7th Edition. Brunswick, 1868. Vol. II., pp. 386–89.]

Galvanisches Tönen.

After describing the production of tones by passing an intermittent current through the coil of an electro-magnet as practised by Wertheim and others, the author says: —

When the breaks [Unterbrechungen] of the electric current follow each other in quick succession, the pitch of the magnetic tone

we have just mentioned is indeed not changed thereby; but there arises simultaneously another tone, which depends on the sum of the magnetic shocks [Stösse] which the iron atoms are subjected to, and has the same pitch as the tone offered by the breaking apparatus itself [Unterbrechungsapparat].

This tone, which arises by the side of the clicking noise, when the magnetic longitudinal tone of the rod is suppressed by the manner in which it is checked, is the one Reis made use of in the construction of his telephone.

Fig. 348 represents Reis's breaking apparatus [Unterbrechungsapparat]. In the cover of the wooden hollow cube A a circular opening is made, which is closed by an elastic membrane (Schweinsdünndarm, — hog's intestine) stretched over it. On the middle of this membrane a little platinum plate is cemented, which, through a very thin metallic strip *f* (more conspicuous in Fig. 349), is connected in circuit with screw *a*. On the middle of the platinum strip a short platinum point rests, which is fastened at *g* on the under side of the piece of metal plate *h g i*, one end *h* of which rests upon little support *l*; whilst a platinum point fastened at *i* on its under side plunges in a hole of little metallic support *k*, said hole containing a small amount of quicksilver. Screw *b* is in electric connection with metallic support *k* [leitender Verbindung].

From one of the poles of a battery a conducting wire goes to screw *a* of the breaking apparatus [Unterbrechungsapparat], Fig. 348; from the other pole of the same a wire goes to screw *d* of the reproducing apparatus, to be mentioned next, Fig. 350. Screw *c* of this apparatus is connected through a wire with *b*, Fig. 348. Screws *c* and *d* are connected with the terminals of the small magnetizing coil M, Fig. 350. By the connection just mentioned the current of the battery passes through the coil.

Now as soon as the sound waves of a sufficiently strong tone get into the mouthpiece of wooden cube A, the elastic membrane which closes the top opening of the same is thrown into vibration. Every entering wave of condensation raises the platinum strip as well as the little point resting thereon, but when the membrane oscillates inwards, the metallic plate *h g i*, with the little point fastened on at *i*, cannot follow quick enough. There occurs then for every vibration

Fig. 348.

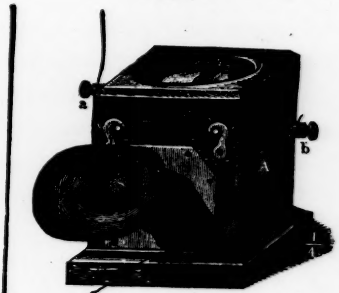


Fig. 349.

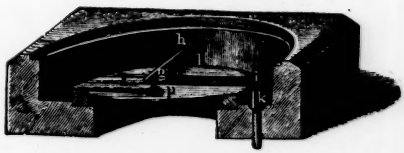
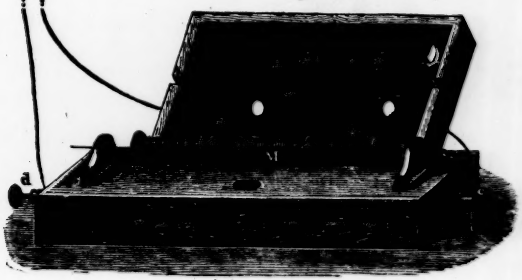


Fig. 350.



of the membrane a break of the current [Unterbrechung des Stromes], which shows itself in a spark occurring at the point of breaking [Unterbrechungsstelle]. Through the coil M runs a knitting needle, which, as the figure shows, is fastened on a sounding board. A cover provided with a second sounding board can be

1950

turned over the coil, and in this way the tone can be much increased.

Now, if tones are produced before mouthpiece *s* by singing into it or playing organ pipes, one hears at the reproducing apparatus, placed as far as convenient at first, a peculiar crackling noise which is independent of the pitch of the tones produced at the breaking apparatus, but, *besides these, tones themselves are distinctly and audibly reproduced by the steel wire;* and Reis found this to be true indeed for all tones between F and $\overline{\overline{f}}$.

In the experiments of Reis, the breaking apparatus was 300 feet distant from the coil; in fact it was placed in another house with closed doors. But as the length of the conductors can be extended just as far as in direct telegraphy, Reis gave to his apparatus the name "telephone" (*Jahresbericht des physicalischen Vereins zu Frankfurt-a-M., Für* 1860/61).

No. 49. — The Manufacturer and Builder, A Monthly Journal devoted to the Advancement and Diffusion of Practical Science, New York, May, 1869, Vol. I., No. 5, pp. 129, 130.

The Telephone, by Dr. Van der Weyde.

One of the most remarkable recent inventions connected with telegraphy is the telephone, an instrument which transmits directly the pitch of a sound by means of a telegraph wire, — either an air wire or submarine cable; so that, for instance, when the operator at one end of the wire sings or plays on an instrument any tune, as "Yankee Doodle" or "Hail Columbia," it will be heard and distinguished plainly at the other end. This invention may, in its present state, have no direct practical application, but be a mere scientific, although highly interesting curiosity; but who can say that it does not contain the germ of a new method of working the telegraph, or some other useful practical purpose?

The telephone is not the result of an accidental discovery, but of a thorough study of the laws of electro-magnetism and of sound. It is founded on the fact that the difference in pitch of different tones

is caused by different velocities of vibrations of the elastic sounding body; which vibrations are transmitted to and by the air with exactly the same velocity, and from the air may be communicated to a properly stretched membrane, like a piece of bladder or very thin sheet of india rubber, stretched like a drum head, which these also will vibrate with exactly the same velocity as the air and the original sounding body, be it the human voice, organ pipe, string or any musical instrument. If, now, at the centre of this little drum head

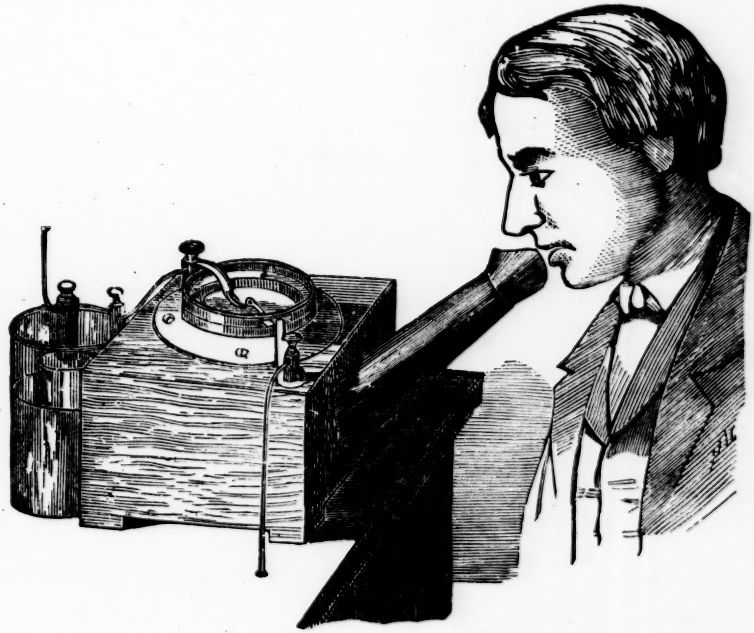


FIG. 2. — TRANSMITTING APPARATUS.

there be attached a small disk of some metal not easily burned by electric currents, — for instance, platinum, — while at the same time a platinum point may, by means of a screw, be so adjusted as to come very nearly in contact with this small platinum disk, it is clear that, when the membrane is put in vibration, a succession of contacts between the disk and point will be produced, of which the number in each second will exactly correspond with the number of vibrations in each second of the sounding body or the tone pro-

duced by it. That part of the apparatus which serves to send off the tune or melody is represented in the illustration, Fig. 2. It consists simply of a square wooden box, provided at the side with a kind of mouthpiece similar to that of a speaking tube, and at the top with an opening, over which the membrane just mentioned has been stretched. The small piece of platinum attached to the centre of this little drumhead is, by means of a very flexible strip of some

FIG. 3. — THE RECEIVER.

metal that conducts well, attached to one pole of the galvanic battery, of which only one cup is represented in the figure, although for a long wire several cups will, of course, be required. The reason why this connection near the platinum disk is a flat, thin and flexible strip is, that any rigidity would interfere with the freedom of vibration of the membrane to which it is attached. The point coming in

contact with this small vibrating disk is connected with the ground wire, the other pole of the battery with the air wire or submarine cable. It is clear, from this explanation, that at every contact of the platinum point a wave of electricity will be sent over the wire, and as many waves in a second as there are contacts; and as there are as many contacts as there are vibrations in every second, the number of electric waves will be always exactly equal to the number of vibrations corresponding with the pitch of each tone, be it fifty, one hundred, two hundred or five hundred in every second.

The instrument in which this succession of waves is made audible at the other end of the telegraph wire is founded on the fact — first investigated by Professor Henry, of the Smithsonian Institute at Washington — that iron bars, when becoming magnetic by means of electric currents passing around them, become slightly elongated, and at the interruption of the current are at once restored to their original length. It is represented in the cut, Fig. 3, and consists of an elongated wooden box, of which the top is made of thin pine wood, similar to the sounding board of a stringed musical instrument, to which are attached two bridges carrying long pieces of moderately thick and very soft iron wire, which, for nearly their whole length, are surrounded by a coil similar to the coil of the electro-magnets used in telegraphing. One end of this coil is attached to the telegraph wire, the other to the ground wire, as represented in the figure. At every instant that a contact is established at the station where the sound is produced, and a current wave thus transmitted, these wires will become magnetic, and consequently elongated; and they will be shortened again at every interruption of the current. And as these currents and interruptions succeed each other with the same velocity as the sound vibrations, the elongations and shortenings of the magnetized iron wires will succeed each other with exactly the same velocity, and consequently they will be thrown into a state of longitudinal vibrations corresponding with the original musical tone, which vibrations will then be communicated to the sounding board in exactly the same manner as is the case with the vibrations of the strings in all stringed instruments, thus becoming more audible at the receiving station.

It is clear, from the foregoing explanations, that no quality of tone can be transmitted. Much less can articulate words be sent, notwithstanding the enthusiastic prediction of some persons, who, when they first beheld this apparatus in operation, exclaimed that now we would talk directly through the wire. It is from its nature able to transmit only pitch and rhythm, — consequently melody, and nothing more. No harmony nor different degrees of strength or other qualities of tone can be transmitted. The receiving instrument, in fact, sings the melodies transmitted, as it were, with its own voice, resembling the humming of an insect, regardless of the quality of the tone which produces the original tune at the other end of the wire.

This instrument is a German invention, and was first exhibited in New York, at the Polytechnic Association of the American Institute, by Dr. Van der Weyde. The original sounds were produced at the farther extremity of the large building (the Cooper Institute), totally out of hearing of the association; and the receiving instrument, standing on the table of the lecture room, produced with its own rather nasal twang the different tunes sung at the other end of the line, rather weakly, it is true, because of the weak battery used, but very distinctly and correctly.

No. 50.—THE TELEGRAPHER, published by the National Telegraphic Union, New York, Vol. V., No. 39, 1869.

(This is a reprint of Dr. Van der Weyde's article, No. 47, *supra*.)

No. 51. — PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, MEETING AT SALEM, AUGUST, 1869.

In the list of papers read is the following: —

"On the audible transmission of musical melodies by means of the electric telegraph. By P. H. Van der Weyde."

[*Article not printed in the proceedings.*]

1955

No. 52. — Boston Daily Advertiser, August 25, 1869.

Report of Meeting of American Association, at Salem.

"Prof. Van der Weyde exhibited the 'telephone,' an instrument for the audible transmission of musical melodies, by means of the electric telegraph. The system is fully described in the May number of the *Architect and Builder*.

"The apparatus to accomplish this is called a telephone. By means of it the operator at one end of the wire sings or plays on an instrument any tune, and it can be heard and plainly distinguished at the other end. The exhibition of the instrument excited much interest."

No. 53. — The Wonders of Electricity, Translated from the French of J. Baile, New York, Scribner, Armstrong & Co., 1872, pp. 140–43.

Wonderful as are these achievements, the inventions in telegraphy have gone still further. To be able to transmit thought to a distance is a triumph which was formerly astonishing; but we are now accustomed to it, and continue to practise it without its creating the slightest wonder. To be able to transmit handwriting and even drawings appeared to be still more difficult; but this problem has also been resolved, and we now hardly wonder that this feat is accomplished by means so simple. Mankind ever requires a new stimulus to its curiosity, and already it is looking forward to the discovery of more marvels in telegraphy. Some years hence, for all we know, we may be able to transmit the vocal message itself, with the very inflection, tone and accent of the speaker. Already has the acoustic telegraph been invented; the principle has been discovered, and it only remains to render the invention practicable and useful, a result which, in these days of science, does not appear to be impossible.

Sound, of whatever kind, is produced by a series of vibrations, more or less rapid, which, setting out from a sonorous body, traverse the air and reach our ear. Just as a stone dropped into a pond throws off a succession of circular undulations or water rings, so a

concussion, acting on the air, produces analogous vibrations, though they are invisible; and it is when these vibrations reach the ear that we become sensible of sound.

An eminent scientific German, M. Helmholtz, has analyzed the human voice and determined its musical value. According to him, each simple vowel is formed by one or more notes of the scale, accompanied by other and feebler notes, which are harmonics of these. He demonstrates that it is the union of all these notes that gives quality to the voice. Each syllable is formed by the notes of the vowel accomplished by different movements of the organs of the mouth. M. Helmholtz, reflecting upon this, thinks it would be possible to construct a human voice by artificially producing and combining the elementary sounds of which it is composed. This is not the place to discuss such theories, but if we grant that there is any truth in them, we can understand that the acoustic telegraph can be invented, and can transmit the living voice. Already experiments have been made in this direction. A vibrating plate produces a sound, and according to the rapidity of the vibrations, these sounds are sharp or flat. At each of the vibrations the plate touches a small point placed in front of it, and this contact suffices to throw the current into the line; when the plate ceases to vibrate and returns to its position of equilibrium, it no longer touches the metal point and the current is consequently interrupted. By this means is obtained a series of interruptions, more or less rapid, according to the sound; the current being thrown into the line and interrupted once for each of the vibrations.

At the extremity of the line the current enters an electro-magnet which attracts another vibrating plate of size and quality identical with the former. Attracted and repelled very rapidly, exactly, and as rapidly, in fact, as the plate mentioned above, this second plate gives forth a sound which will have the same musical value as that of the other, as the number of vibrations per second is the same in both cases.

Should this process be perfected, it will be possible to transmit sound by means of the telegraph, to transmit a series of sounds, a tune, or spoken sentence and conversation. This consummation has not, however, been yet attained. Many experiments have been made,

the principle has been applied in divers ways, and everything makes us hope that we will yet arrive at a perfect system of acoustic telegraphy. Advances have been made very far upon the road to success. A series of vibrating plates answering to the strings of a harp, has been arranged, each of which vibrates when struck by a particular sound, and sends off electricity to create at the end of the line the same vibrations in a corresponding plate, or, in other words, to produce the same sound.

This system, it must be admitted, is at least very ingenious. Experiments have been made in laboratories, that is to say, under conditions entirely favorable, and such as we would not often find in actual practice. Under these conditions a musical air has actually been successfully transmitted by this acoustic telegraph. All must admit that this is a promising beginning; but we must not make too much haste to exalt the miracle and to extol the advantages of the future machine, or to abandon ourselves to the indulgence in indiscriminate laudation on the strength of this new discovery. That would be a gross mistake and an injury to science. True scientific faith is doubt, until the truth appears in uncontrovertible clearness. Care must be taken not to take for reality that which is merely a desire on our part. We must guard against all premature exultation, because it weakens us in the search for truth, and because even one deception is cruel. Let us therefore give to doubt, to patience and to perseverance the place which some too readily give to congratulation.

No. 54. — DAS BUCH DER ERFINDUNGEN, GEWERBE UND INDUSTRIEN, Leipzig, 1872.

[Book of Inventions, Trades and Industries.]

TELEPHONY.

It sounds more than wonderful when the possibility is asserted of carrying on a conversation with another person at a distance of hundreds of miles through the electric telegraph wire, so that he can hear with his bodily ear our voice with all its peculiarities, that he should hear the melody we are singing, and that he should feel, when we laugh, precisely as if he was standing alongside of us,

But this possibility has, to a certain degree, already become to be a fact.

The master teacher, Reis, in Frankfurt-on-the-Main, had the good idea to make of the electro-magnetic telegraph "which has hitherto been an eye reaching over many lands," an ear which should reach full as far.

In this strange organ of hearing, the electro-magnetic apparatus takes the part of those bones of the ear which carry the commotion from one membrane to another, and the only difference between the cavity of the ear and the union of two such stations, is, that in one case we are made sensible of the striking of the sound waves against the ear drum by means of a lever, and in the other by means of the commotion of an iron rod.

Figure 417 shows us Reis's telephone, which has the following construction: —

At the first station I, there is a hollow box with a sound receiver A in front; into this sound receiver you sing the melody which you wish your distant hearer to hear. On top of the box there is an opening tightly covered with a membrane of swinegut *m*; on top of this membrane there lies a very thin plate of platina *p*, which is touched by the point of a pencil *n*, made of platina with a very sensitive spring; the point of this pencil is placed so that it will but just touch the plate *p* when the membrane is motionless, but leaves the same by each motion, when the same swing to and fro. This alternate touch and separation stops and starts the electric current, which comes from the Bunsen battery (three to four elements) and goes through the binding screw *a* into the plate *p*, and out of that into the pencil *n*, and to the second binding screw *b*. From *b* the wire leads to the second station and around the spiral C C, and goes from there through the binding screw *d*, and through the wire *c* connected therewith back into the battery. In the centre of the spiral lies a small iron rod, fastened on both ends to the bridges *f f*, which rest on the sounding board *g g*. The parts *h*, *i*, *k*, *l*, in both stations, belong to a telegraphic arrangement by means of which the attention of the distant audience may be called to the beginning of a message. The reproduction of a sound depends now mainly upon the commotion of the iron rod, which is magnetized by the

electric current moving around the spiral. As insignificant as each single movement of the smallest part may appear, they are strong enough to give the sensation of a sound through their regular and quick repeating, and the assistance of the sounding board. The succession of the currents going through, depends on the vibration of the membrane *m*, in the first station, and consequently, the sound reproduced in the second station must be in regard to its pitch, in perfect accord with the sound sung into the sound receiver A.

As early as October, 1861, Reis had made successful trials with his apparatus. A melody sung with a medium loud voice was reproduced perfectly at a distance of one hundred metres. Although the problem of "far speaking" may so far only be considered solved in theory, and the apparatus has not yet that perfection which would make it possible for a speaker to interest large gatherings at numerous distant parts of the earth, it is nevertheless interesting enough to be described in this place.

No. 55. — Catalogue of J. Wilh. Albert, Mechanician, at Frankfort-on-the-Main, 1873.

Extract from Preface. "All instruments and apparatus will always be constructed according to the latest designs and improvements. In order that their construction may be better understood, we have printed herein references where a more complete description can be found as follows: —

"M.-P. Müller-Pouillet's Lehrbuch der Physik VII Auflage.

"A list of other books is given."

In the body of the catalogue is the following: —

"957. Telephone of Reis for reproduction of tones by electricity, with description, 21 florins, 36 Rm.

"(M.-P. Fig. 348, bis. 350: Pisco, Akustik, Fig. 60.)

"958. The same with a simple electro-magnetic signalling apparatus. 26 fl. 15 kr.-45 Rm."

No. 56. — DIE LEHRE VOM GALVANISMUS, von Gustav Wiedemann, Braunschweig, 1874, Vol. II., pp. 598, 599.

[Lessons in Electricity, by Wiedemann, Brunswick, 1874.]

A sheet-iron plate, twenty centimeter diameter, secured in the centre and placed close over the opening in a helix, which is mounted with its axis in a vertical line, furnished bell-like tones when the current in the helix was opened and closed, as if the plate had been set into rotary vibrations by a violin bow rubbing around the edges of the same. A thin sheet of tinned iron is thereby depressed around its edges towards the spiral, and is elevated again when the current is opened, so that here also the tones are based on an electro-magnetic movement of the plate, which, by reason of the unequal elasticity and the unequal distance of the edges from the spiral becomes irregular, and thus gives no occasion for the formation of distinct nodal lines.

Nor does the location of nodal lines of sand, formed, say when the plate is rubbed by a bow, change under the influence of the magnetizing. In addition to the longitudinal tone of rods, which appears already when the same are magnetized once by a current and interruption of current, one observes when the interruptions of the magnetizing current is repeated, a rattling noise which, when the interruptions are rapid, develops into a tone, the vibrational number of which is equal to the number of current interruptions.

This rattle-tone [Klirrton] is much less distinct with thin steel rods, but the original longitudinal tone much stronger and purer than with rods of soft iron. These tones may already occur in the case of very rapid interruptions.

If, as in the Telephone of Reiss,* a membrane is secured to a small box which is provided with a sound opening, which membrane carries upon its centre a thin platinum plate connected to a binding screw by means of a small strip of platinum; and if a point, which is almost in contact with the platinum plate and is carried by an angular metal piece connected to a binding screw, is secured to the box, then a current which passes through the angular piece and through the plate will be closed when a tone is sung before the sound opening, as many times as there are vibrations to the tone, in consequence of the

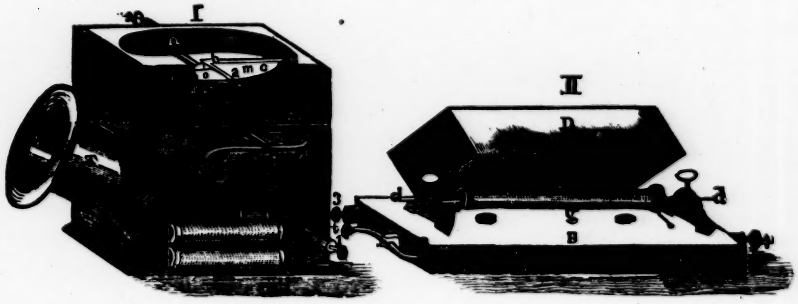
* Reiss, see Kuhn's Angewandte Electricitatslehre, Vol. II., p. 1020, 18*.

oscillations of the membrane. If now the current is directed through a helix about eighteen centimeter long, and consisting of six layers of thin copper wire, secured to a resonating plate, through the axis of which helix passes a knitting needle, about twenty to thirty centimeter long, which also passes with its ends through two bearings, the needle will also sound the tone sung into the sound opening, like a buzz [Summen].

No. 57. — Scientific American, New York, March 4, 1876.

The Invention of the Telephone, by P. H. Van der Weyde, M. D.

In connection with Mr. Gray's application of the telephone to the simultaneous transmission of several different telegraphic messages over one wire at the same time, and his paper read before the American Electrical Society (published on p. 92, *Scientific American*, Supplement for Feb. 5), it may be interesting for the readers of this paper to obtain some information in regard to the invention of the telephone, by Reuss. As mentioned in the article above referred to, Page and Henry observed that, by rapid magnetization and demagnetization, iron could be put into vibrations isochronic with the interruptions of the current; and later, Marian experimented extensively in this direction, while Wertheim made a thorough investigation of the subject, which induced Reuss, of Friedrichsdorf, near Hamburg, Germany, to apply this principle to the transmission of musical tones and melodies by telegraph; and he contrived an apparatus which we represent in the engravings.



Professor Reuss's Telephone.

The telephone of Reuss consists of two parts, the transmitting and the receiving instrument. Fig. I. represents the former, and is placed at the locality where the music is produced; Fig. II., the latter, is placed at the station where the music is to be heard, which may be at a distance of 100, 200 or more miles; in fact, as far as the battery used can carry the current; while the two instruments are connected with the battery and the telegraph wire in the usual manner. One pole of the battery is connected with the ground plate, the other with the screw, marked 2 in our Fig. I., and thence over a thin copper strip *n*, with the platinum disk *o*, attached to the centre of the membrane stretched in the large top opening of the hollow and empty box K, intended to receive and strengthen the vibrations of the air, produced by singing before the funnel-shaped short tube attached to the opening in T. Over the platinum disk *c*, attached to the elastic membrane, is a platinum point attached to the arms *b c* and *b* K, while a set-screw brings this point in slight contact with the platinum disk mentioned. A part of the box is represented as broken and removed, in order to show the internal construction. The strip *a b c*, is connected with the end *s*, of the switch *t s*, and the screw connection 1, at the lower right-hand corner, and also through the telegraph wire, to the instrument Fig. II., at the receiving station, which may be situated at a distance of many miles. Here the current enters by the screw connection 3, and passes through the spiral *g*, surrounding the soft iron wire *d d*, of the thickness of a knitting needle, and leaves the apparatus at the screw connection 4, whence it obtains access to the ground plate, and so passes, through the earth, back to the battery. The spiral and iron wire *d d*, is supported on a hollow box B, of thin board; while a cover D, of the same material is placed on top, all intended to strengthen the sound produced by the vibrations which the interruption of the current caused in the iron wire *d d*, so as to make these vibrations more audible by giving a large vibratory surface, in the same way that the sounding board of a piano-forte strengthens the vibrations of the air caused by the strings, and makes a very weak sound quite powerful.

If a flute be played before the opening T, or if a voice be singing there, the vibration of the air inside the box K, causes the membrane *m*, to vibrate synchronically, and this causes the platinum disk *o*, to

move up and down with corresponding frequency. At every downward motion the contact of this disk with the platinum point, under *b*, is broken, and therefore the current is interrupted as rapidly as the vibrations occur. Let, for instance, the note C be sounded; this note makes sixty-four full vibrations in a second, and we have therefore sixty-four interruptions of the electric current, which interruption will at once be transmitted through the telegraph lines to the receiving instrument, and put the bar *d d*, into exactly similar vibrations, making the very same tone C, audible; and so on for all other rates of vibration. It is clear that in this way not only the rhythm of music can be transmitted (and this can be done by the ordinary telegraph), but the very tones, as well as the relative durations and the rests between them, can thus be sent, making a full and complete melody. The switch *t s*, Fig. I., is intended, in connection with a similar one in Fig. II., to communicate between the stations, with the help of the electro-magnet E, to ascertain if station, Fig. II., is ready to receive the melodies; then it gives the signal, by manipulating the switch, which is received by the attraction of the armature A, the latter arrangement being a simple Morse apparatus attached to the telephone.

Professor Heisler, in his "*Lehrbuch der technischen Physik*" (3d edition, Vienna, 1866), says, in regard to this instrument: "The telephone is still in its infancy; however, by the use of batteries of proper strength, it already transmits not only single musical tones, but even the most intricate melodies, sung at one end of the line to the other, situated at a great distance, and makes them perceptible there with all the desirable distinctness." After reading this account in 1868, I had two such telephones constructed, and exhibited them at the meeting of the Polytechnic Club of the American Institute. The original sounds were produced at the further extremity of the large building (the Cooper Institute), totally out of hearing of the Association, and the receiving instrument, standing on the table in the lecture room, produced (with a peculiar and rather nasal twang) the different tunes sung into the box K, at the other end of the line; not powerfully, it is true, but very distinctly and correctly. In the succeeding summer I improved the form of the box K, so as to produce a more powerful vibration of the membrane, by means of reflec-

tions effected by curving the sides; I also improved the receiving instrument by introducing several iron wires in the coil, so as to produce a stronger vibration. I submitted these, with some other improvements, to the meeting of the American Association for the Advancement of Science, and on that occasion (now seven years ago) expressed the opinion that the instrument contained the germ of a new method of working the electric telegraph, and would undoubtedly lead to further improvements in this branch of science, needing only that a competent person give it his undivided attention, so as to develop out of it all that it is evidently capable of producing.

Before leaving this subject I wish to draw special attention to the fact that the merits of this invention consist chiefly in the absence of musical instruments, tuning forks, or their equivalents, for producing the tones; any instrument will do; flute, violin, human voice, etc. If the aërial vibrations are only connected into the box, Fig. I., the apparatus will send the pitch as well as the duration of the different tones, with the rests between, therefore not only transmitting perfect rhythm, but a complete melody, with its long and short notes. The two parts of the apparatus may even be connected each to a separate piano-forte; and if this were done in a proper manner, a melody played on the piano-forte connected with the transmitting instrument, Fig. I., would be heard in the piano-forte at a great distance, connected with the receiving instrument, Fig. II.

No. 58. — REPORT OF THE EXHIBITION OF SCIENTIFIC APPARATUSES IN SOUTH KENSINGTON MUSEUM, LONDON, 1876. ALSO A COMPLETE AND DESCRIPTIVE CATALOGUE OF THE EXHIBITION WITH ENGRAVINGS OLLEIED BY THE ROYAL COUNCIL OF EDUCATION. Arranged by Dr. Rudolf Biedermann, London, 1877.

"P. 188. Group 6. *Sound.*

"922. Telephone, after J. Reis, for the reproduction of tones by electricity, J. W. Albert, Frankfort-a-M.

"The telephone is based on the experiments of Wertheim and others on galvanic sounds. Philip Reis of Friedrichsdorf made use of this for the reproduction of musical tones produced by singing

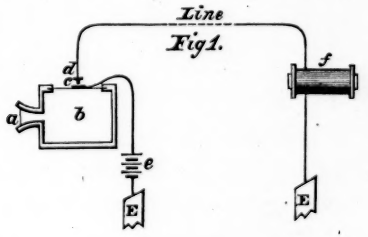
(wind instruments, etc.) by way of electricity with the aid of an elastic membrane and a breaking apparatus constructed by him. (Vide annual report of the Physical Society of Frankfort-a-M., of 1860–61; also Müller's Lehrbuch der Physick VII. Ed., 2d Vol. p. 135.)"

ARTICLES ABOUT REIS AFTER THE BELL PATENT, AND BEFORE THE MICROPHONE WAS KNOWN.

No. 59. — Report of the Forty-seventh Meeting of the British Association for the Advancement of Science, held at Plymouth in August, 1877.

On the Telephone, by W. H. Preece, Memb. Inst. C. E., etc.

Phillip Reis, of Friedrichsdorf, in 1861, produced the first telephone which reproduced musical sounds at a distance. He utilized the discovery of Page by causing a vibrating diaphragm to rapidly make and break a galvanic circuit. The principle of his apparatus is shown in Fig. 1 annexed, in which in the diagram (*b*) is a hollow wooden box into which the operator sings through the mouthpiece (*a*).



The sound of his voice throws the diaphragm (*c*) into rapid vibration, so as to make and break contact at the platinum points (*d*) at each vibration. This interrupts the current flowing from the battery (*e*) as often as the diaphragm vibrates, and therefore magnetizes and demagnetizes the electro-magnet as often. Hence whatever note be sounded into the box (*a*), the diaphragm (*c*) will vibrate to the note, and the electro-magnet *f* will similarly respond, and therefore repeat that note.

Musical sounds vary in tone, in intensity and in quality. The tone depends on the number of vibrations per second only; the in-

tensity on the amplitude or extent of those vibrations; the quality on the form of the waves made by the vibrating particles of air.

It is evident that in Reis's telephone everything at the receiving end remains the same, excepting the number of vibrations, and therefore the sounds emitted by it varied only in tone, and were therefore notes and nothing more. The instrument remained a pretty philosophical toy, and was of no practical value.

Cromwell Varley, in 1870, showed how sounds could be produced by rapidly charging and discharging a condenser.

No. 60. — ELEMENTARY TREATISE ON PHYSICS, Ganot, 8th Edition, translated by E. Atkinson, New York, 1877, p. 757.

"Reis's telephone consists essentially of a membrane which is put in vibration by producing musical sounds in front of a convenient mouthpiece. The apparatus is so arranged that these vibrations alternately open and close a current which produces at any distance sounds by such an arrangement as the above."

No. 61. — THE TELEPHONE, by Prof. A. E. Dolbear, Boston, Lee & Shepard, 1877, pp. 99–116.

Having treated at some length of the three factors involved in telephony, — namely, electricity, magnetism and sound, — it remains to follow up the various steps that have led to the actual transmission of musical sounds and speech over an ordinary electric circuit.

It is stated upon p. 31, that, when a current of electricity is passed through a coil of wire that surrounds a rod of soft iron, the latter is made a temporary magnet; it loses its magnetic property the instant that the current ceases. If the rod be of considerable size, say a foot or more in length, and half an inch or more in diameter, and the current be strong enough to make a powerful magnet of it, whenever the current from the battery is broken, the bar may be heard to give out a single *click*. This will happen as often as the current is broken. This is occasioned by a molecular movement which results in a *change* of *length* of the bar. When it is

made a magnet, it elongates about $\frac{1}{2500}$ of its length; and, when it loses its magnetism, it *suddenly* regains its original length; and this change is accompanied with the sound. This sound was first noticed by Professor C. G. Page, of Salem, Mass., in 1837. If some means be devised for breaking such a circuit more than fifteen or sixteen times a second, we shall have a continuous sound with a pitch depending upon the number of clicks per second. Such a device was first invented by the same man, and was accomplished by fixing the armature of an electro-magnet to a spring which was in the circuit when the spring was pressing against a metallic knob, at which time the current made the circuit in the coil of the electro-magnet. The magnet attracting the armature away from the button broke the circuit, which of course destroyed the magnetism of the magnet, and allowed the spring to fly back against the button, to complete the circuit, and reproduce the same series of changes. The rapidity with which the current may be broken in this way is only limited by the strength of both spring and current. The greater the tension of the spring with a given current, the greater number of vibrations will it make.

Suppose such an intermittent current to pass through the coil surrounding the soft iron rod 256 times per second; then the rod would evidently give 256 clicks per second, which would have the pitch of C. When these clicks are produced in the rod held in the hand, the sound is hardly perceptible, being like that of a sounding tuning-fork when held thus. In order to strengthen it, it is necessary to place it on some resonant surface. It is customary to

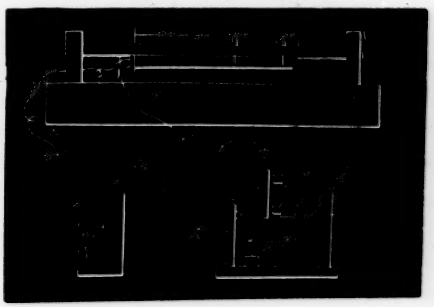


FIG. 11.

mount it upon an oblong box with one or two holes in its upper surface, inasmuch as such a form is found to give a louder response than any other, and is the shape usually given to æolian harps. The accompanying cut shows the combination of battery B, the circuit-breaker, and the rod mounted upon the box. The wire W may evidently be of any length, the magnetized rod and box responding to the number of vibrations of the spring S, how long soever the circuit may be.

HELMHOLTZ'S ELECTRIC INTERRUPTOR.

In some of Helmholtz's experiments, it was essential to maintain the vibrations of a tuning-fork for a considerable time. He effected this by placing a short electro-magnet between the prongs of the fork, and affixing a platinum point at the end of one prong in such a manner, that, as the prong descended in its vibration, the platinum point dipped into a small cup of mercury that completed the circuit. When the prong receded, it was of course withdrawn from the mercury and the current was broken. As it is not possible for a tuning-fork to vibrate in more than one period, such an arrangement would evidently make and break the current as many times per second as the fork vibrated. When, therefore, such an interruptor is inserted in the circuit with the click-rod on its resonant box, the latter must give out just such a sound as the fork is giving. With such a device, it is possible to reproduce, at almost any distance in a telegraphic circuit, a sound of a given pitch. It is therefore a true telephone.

REISS'S TELEPHONE.

The ease with which membranes are thrown into vibrations corresponding in period to that of the sounding body has already been alluded to on p. 80; and several attempts have been made, at different times, to make membranes available in telephony. The first of these attempts was made by Philip Reiss, of Friedrichsdorf, Germany, in 1861.

His apparatus consisted of a hollow box, with two apertures: one in front, in which was inserted a short tube for producing the sound in, and indicated by the arrow in the cut, Fig. 12; the other on the

1969

top. This was covered with the membrane *m*, — a piece of bladder stretched tight over it. Upon the middle of the membrane a thin piece of platinum was glued; and this piece of platinum was connected by a wire to a screw cup from which another wire went to a battery.

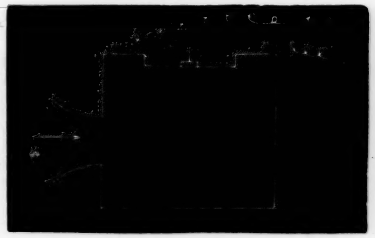


FIG. 12.

A platinum finger S, rested upon the strip of platinum, but was made fast at one end to the screw cup that connected with the other wire from the battery. Now, when a sound is made in the box, the membrane is made to vibrate powerfully; this makes the platinum strip to strike as often upon the platinum finger, and as often to bound away from it, thus making and breaking the current the same number of times per second. If, then, a person sings into this box while it is in circuit with the aforementioned click-rod and box, the latter will evidently change its pitch as often as it is changed by the voice. In this apparatus we have a telephone with which a melody may be reproduced at a distance with distinctness. But the sounds are not loud, and they have a tin-trumpet quality. If one reflects upon the possibilities of such a mechanism, and upon the conditions necessary to produce a sound of any given quality, as that of the voice or of a musical instrument as described in preceding pages, he will understand that it can reproduce only pitch. It might here be inferred that something more than a single pitch is transmitted if the sound is like that of a tin trumpet, as stated; but the reason of this is that, whenever a current is passing between two surfaces that can move only slightly on each other, there is always an irregularity in the conduction, so as to produce a kind of scratching sound; and it is this, combined with the other, the true pitch, that gives the character to the sound of this instrument.

Dr. Wright found that a sound of considerable intensity could be obtained by passing the interrupted current through the primary wire of a small induction coil, and placing a conductor made of two sheets of silvered paper placed back to back in the secondary circuit. The silvered paper becomes rapidly charged and discharged, making a sound that can be heard over a large hall, and having the same pitch as the sending instrument.

1971.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all persons to whom these Presents shall come, Greeting:

This is to certify that the annexed is a translation, by the Official Translator, from the bound volumes of this office, of the specification, in the matter of the German Letters Patent, granted Robert Lüdtge, January 12th, 1878, Number 4,000, for Improvement in Transmitter and Relay for Electric Telephones, together with a tracing of the drawing forming part of said patent.

In testimony whereof I, M. V. Montgomery, Commissioner of Patents, have caused the Seal of the Patent Office to be affixed this 7th day of October, in the year of our Lord one thousand eight hundred and eighty-six, and of the Independence of the United States the one hundred and eleventh.

[SEAL] M. V. MONTGOMERY,

Commissioner.

GERMAN PATENT 4,000. ROBERT LÜDTGE IN BERLIN.

TRANSMITTER AND RELAY FOR ELECTRIC TELEPHONES.

PATENTED IN GERMANY, 12 JANUARY, 1878.

The principle and the construction of the Bell Telephone entail, in so far as it is used for receiver and transmitter, several inconveniences that cannot be removed without a change of principle, but which interfere with its employment for long distances as well as for household uses. The fact that the instrument is constructed only for induction currents and is very sensitive to these same, alone introduces the annoying adjunct, that all other disturbing operations of induction, such as working on collateral lines, make themselves very perceptible. The fact that these induction currents are engendered by the vibrations of the air produced by our mouths alone without the assistance of any ulterior source of power, make them seem too weak for intercourse over large lines, and for domestic use not sufficient to compete with the disturbing noises in the neighborhood.

Considerable progress is made towards meeting these objections by using for telephoning not induction, but battery currents, that offer the further advantage, that, as a new additional source of power, they allow the operation to be intensified. In this connection several experiments have already been made and their results published.

Before all such, must be mentioned the telephone invented by Reis in 1863, but the trouble with that is, that in response to the vibrations of sound, it only just opens or closes the battery current. The greater or less intensity or amplitude of the sound waves can, therefore, not express itself in a greater or less intensity of the battery current. The more delicate relations of vibrations which is the first thing to characterize a letter or a word find no expression, hence disappear in the final operation which, in consequence, consists almost solely of the repetition of the rhythm of the fundamental tone.

Furthermore, there belongs in this class the telephone of Edison, in New York, which uses the vibrations of a metal plate that is talked at, more or less to compress an appropriately applied piece of graphite introduced into the circuit of a battery, and inasmuch as the resistance of the graphite is influenced by the pressure so the intensity of the current is changed by the vibrations of the plate. The present invention is founded essentially on the following discovery : —

If a point of interruption is introduced in the circuit of the battery, say by simply cutting the conducting wire, and laying the two cut surfaces against each other, a passage resistance will arise at the point of the cut that will be smaller in proportion as the two cut surfaces press more strongly against one another. This fact is easily verified by the aid of a sufficiently sensitive galvanometer; it can also be verified by a Bell Telephone introduced into the circuit, as it can then be distinctly heard how the current is restored when the two cut surfaces are brought together again, and then how it is changed in intensity according to the force with which the surfaces are pressed together.

Now, if the one cut surface be so constructed as to be set in vibra-

1973

tion by speaking or other noise, it will be made to press upon the other cut surface in contact with it variously according to the intensity and form of the single vibrations. The passage resistance at this point will be exactly influenced in magnitude by the intensity, form and number of sound vibrations of the sounding surface and therewith determines also the intensity of the battery current already existing in the circuit. In other words, each sound vibration which the sounding surface performs, causes a simultaneous increase of intensity of the battery current exactly corresponding to the amplitude of the sound vibration, and a Bell Telephone introduced into the circuit will translate this increase of intensity back again into the corresponding operation of sound. As this process is valid for every vibration, the Bell Telephone acting as receiver will allow all the vibrations to be heard that are produced by the one cut surface at the point of interruption acting as a transmitter, and that, too, with all the refinements, as no closing and opening of the current takes place, but merely an increase or decrease of intensity according to the force of the pressure with which the two surfaces touch, and which in this case is altered only by the vibrations executed by one surface against the other when giving forth sound or else being talked at.

From what has gone before it is clear what principle it is that serves as a foundation for the present invention. Now follows the constructive application of this principle: —

The construction finds as its most essential problem the manner in which the two ends of the point of interruption, hitherto designated as "cut surfaces" shall be shaped, in view of the object to be attained. These two ends must remain uninterruptedly in contact, so that the circuit shall always remain closed, but the intimacy of their contact must be so slight that at the point of interruption a perceptible passage resistance is offered to the electricity; that the intimacy of the contact and with it the passage resistance shall vary as soon as one *or** both of the two ends is set into sound vibration.

In this connection it must be observed that the contact for thi

*Misprint in the German "ober" for "oder."

1974

reason must not be too intimate, that the sound vibrations of the one end must always be perceptible to say the least.

To solve this difficulty various constructions have been applied each especially suited for some peculiar collateral purpose. The following parts are common to all the different constructions : —

1. A battery for developing electricity. The strength of the same depends on the length of the circuit, intensity of operation to be produced, etc.

2. A conductor of ordinary electric conducting wire.

3. A telephone of Bell construction introduced into the circuit at the receiving station to receive the despatches.

For the transmitter introduced into the circuit at the transmitter station and forming the object of this invention, the following constructions have given the best results : —

The first construction is shown by Fig. 1, of the accompanying drawing. Against a round, smooth metallic plate *a* (sheet iron, sheet zinc, thin silvered glass, etc.), fastened in a wooden ring from 2 to 10 cm. in diameter and not thicker than 1 mm. set in connection with one pole of the battery by the wire *b* or else by the ground wire, there is pressed a metallic pin *c* connected with the other pole of the battery (adjusted) by means of a micrometer stand and screw *d*, so that it touches the plate gently and closes the circuit by means of the conducting wire *e*. Now if speech or song is directed against the plate *a*, then the intimacy of the contact between plate and pin will be varied and the required operation produced. The micrometer screw must be cut very fine to admit of the most advantageous adjustment of the pin, and as the apparatus is sensitive to the slightest jar, it will be advisable to set it up on an insulating column. Unavoidable changes of temperature occasion a frequent readjustment. Due consideration being had for these inconveniences in accordance with the exigencies of the case, this construction will commend itself by its very great sensitiveness and its very favorable intensity at the receiver station. Furthermore, in Fig. 1, *f* is the wooden shell, (fastening), *g* the speaking trumpet, *h* the battery, *i* the ground plate, *k* an insulating layer for the platinum point, *l* clamp screws,

1975

m the spindle of the micrometer screw, n the receiver. The pin c can also be replaced by a second plate b as shown in Fig. 2. In this case the micrometer screw is replaced by a screw-threaded brass ring l, to adjust the relative positions of the plates a and b. In this construction it is indifferent which of the plates is spoken at. It is better to vault one of the two plates, as shown in Fig. 2.

Furthermore, in the same figure, h is the wooden ring for enclosing the whole, p the wooden ring for holding the plate b fast, l and q brass rings screw-threaded, m clamp-screws for the conductors r and s. A second method of securing the proper contact of the plate a, with the pin c, or the other plate, is to allow the pin or the plate to lie upon the plate a, with its own weight.

This construction is shown in Fig. 3 for plate and pin, and in Fig. 4 for two plates. The pin c stands vertical, moving easily in a metal tube b, but always in conducting contact. It is gently pressed by its own weight upon the plate a. The intimacy of this contact is regulated first by the weight of the pin, then by the inclination given to the whole apparatus. The meaning of the remaining letters in Fig. 3 is as follows: a arm for the contact pin, r oscillating plate, f wooden fastening (shell), w clamp screws, l conducting wires, E receiving station, B battery. In using the plate, Fig. 4, the means of adjustment remain the same, the plates a and b are introduced into the circuit by thin wires r and s.

A third method of adjusting the contact both for plate and pin and for two plates is shown in Fig. 3. In other respects the construction is like the preceding, only that underneath the plate a magnet or electro-magnet m, is applied whose attraction for the iron pin or plate above the oscillating plate serves to regulate the intimacy of contact. A fourth method shown in Fig. 5 is by adjusting and fastening the two contact plates by pads of wadding, a construction distinguished for its simplicity and handiness if not for great (excellence of) operation.

In general the constructions with two plates are more durable and simpler to manipulate, and work much neater and cleaner. But the pin and plate construction works with greater sensitiveness and intensity. It will be clear from what has gone before, that all constructions mentioned will fit for the use of the transmitter as a relay,

as Fig. 6 shows. In this case the plate *a* is identical with the iron plate of the Bell Telephone, only it is set in vibration now, not directly by the voice but by inductive and magnetic forces operating below it called into action at the transmitter, and then propagates the vibrations received to the receiving station as a transmitting apparatus would do.

Claim. The construction of a telephone transmitter which operates by means of the variations produced by sound vibrations in the intimacy of contact of two or more solid electric conductors, is driven by battery currents and can also be used as a relay in telephone establishments.

ROBERT LUDTGE IN BERLIN.

Aufgabe-Apparate und Relais für elektrische Fernsprech-Einrichtungen.

Fig. 1.

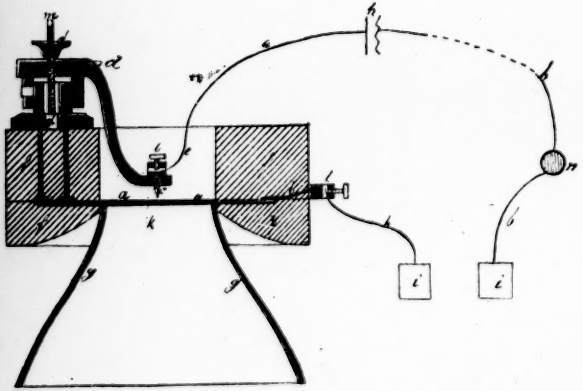


Fig. 3.

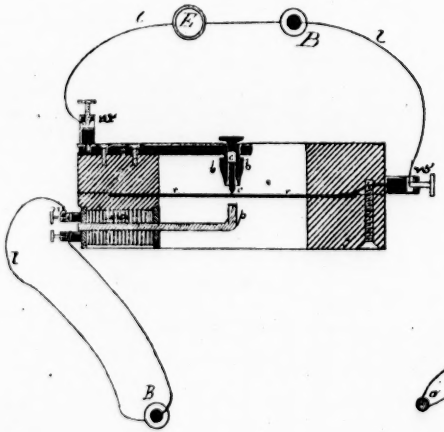


Fig. 6.

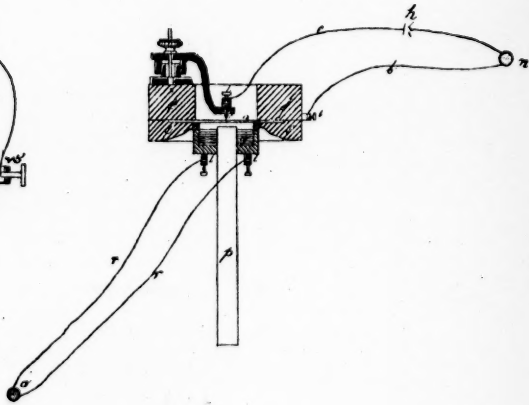


Fig. 2.

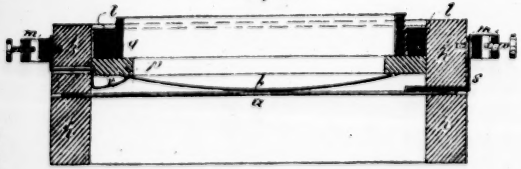


Fig. 4.

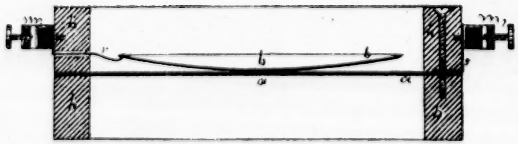
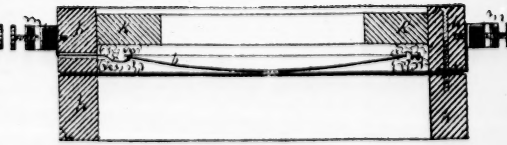


Fig. 5.



PHOTOGR. DRUCK DER KÖNIGL. PREUSS. STAATSDRUCKEREI.

Zu der Patentschrift

№ 4000.

(Note by Clerk, U. S. Circuit Court, S. D. of N. Y.) Drawing of Ludtge Patent of 1878, referred to in index (p. 1971), to be inserted if furnished before record is sent to Supreme Court. If not, to be added afterwards under general stipulation on page 4180 of record.

AMERICAN BELL TELEPHONE COMPANY

1977

FILE WRAPPER AND CONTENTS OF PATENT TO ALEXANDER GRAHAM BELL, NO. 174,465, ISSUED MARCH 7, 1876.

[Printed from certified photographic copy of the original papers on file at the Patent Office, and carefully compared with said certified photographic copy.

The application itself is printed line for line and page for page with the photograph.]

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, greeting:

This is to certify that the annexed are full-sized photographic fac-similes of the file wrapper and contents and full-sized copies of the original drawings, as filed in the matter of Letters Patent granted Alexander Graham Bell, March 7th, 1876, No. 174,465, for Improvement in Telegraphy.

In testimony whereof I, M. V. Montgomery, Commissioner of Patents, have caused the seal of the Patent Office to be affixed this 30th day of October, in the year of our [SEAL] Lord one thousand eight hundred and eighty-five, and of the Independence of the United States the one hundred and tenth.

M. V. MONTGOMERY,
Commissioner.

To the Commissioner of Patents.

Your petitioner *Alexander Gra-*
-ham Bell, of *Salem*, *Massachusetts*, prays that letters patent may be granted to him for the invention set forth in the annexed specification.

And he hereby appoints Pollok & Bailey of Washington D. C. his Attorneys with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the pat-
-ent, and to transact all business in the Patent Office connected therewith.

No Model required
POLLOK & BAILEY

Witnesses to Signature
Thomas E. Barry
P D Richards

Alex. Graham Bell

To whom it may concern: Be it known that I, Alexander Graham Bell of Salem Massachusetts, have invented certain new and useful Improvements in Telegraphy, of which the following is a specification.

In letters patent granted to me April 6, 1875, No. 161,739, I have described a method of, and apparatus for transmitting two or more tel--egraphic signals simultaneously along a single wire by the employment of trans--mitting instruments – each of which occa--sions a succession of electrical impulses differing in rate from the others; and of receiving instruments – each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting instruments and of vibratory circuit breakers operating to con--vert the vibratory movement of the receiv--ing instrument into a permanent make or break (as the case may be) of a local circuit in which is placed a Morse sounder, register or other telegraphic ap--paratus. I have also therein described a form of Autograph Telegraph based upon the action of the above-mentioned instruments.

1979

In illustration of my method of multiple telegraphy I have shown in the patent aforesaid as one form of transmitting instrument an electro-magnet having a steel-spring arma--ture which is kept in vibration by the action of a local battery. This armature in vibrating makes and breaks the main circuit, producing an intermittent current upon the line-wire. I have found however that upon this plan the limit to the num--ber of signals that can be sent simul--taneously over the same wire is very speedily reached; for, when a number of transmitting instruments – having different rates of vibration are simultaneously making and breaking the same circuit – the effect upon the main line is practically equivalent to one continuous current.

Erase & insert per Amd't A. Febr. 29 '76

[My present invention consists in the employment of a vibratory current of elec--tricity in place of a merely intermittent one; and of a method of, and apparatus for, producing electrical undulations upon the line-wire.]

The advantages I claim to derive from the use of an undulatory current in place of a merely intermittent one – are:

1. That a very much larger number

of signals can be transmitted simultaneously on the same circuit.

2. That a closed circuit and single main battery may be used.

3. That communication in both directions is established without the necessity of special induction coils

4. That cable despatches may be transmitted more rapidly than by means of an in--termittent current or by the methods at present in use; for, as it is unnecessa--ry to discharge the cable before a new signal can be made – the lagging of cable-signals is prevented.

5. And that – as the circuit is never broken a spark-arrester becomes unnecessary.

It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet a current of electricity is induced in the coils of the latter; and that when it is made to recede a current of opposite polarity to the first appears upon the wire. When therefore a permanent magnet is caused to vibrate in front of the pole of an electro-magnet, an un--dulatory current of electricity is induced in the coils of the electro-magnet, the

undulations of which correspond, in rapidity of succession, to the vibrations of the magnet, in polarity to the direction of its motion; and in intensity to the amplitude of its vibra--tion.

That the difference between an undulato--ry and an intermittent current may be more clearly understood, I shall describe the condition of the electrical current when the attempt is made to transmit two musical notes simultaneously – first upon the one plan and then upon the other.

Let the interval between the two sounds be a major third; then their rates of vibra--tion are in the ratio of 4 : 5. Now when the intermittent current is used the circuit is made and broken four times by one transmitting instrument – in the same time that five makes and breaks are caused by the other. A and B, Figures 1, 2, and 3, represent the intermittent currents produced, four impulses of B, being made in the same time as five impulses of A. *c c c*, &c show where and for how long time the circuit is made, and *d d d*, &c indicate the duration of the breaks of the circuit. The line A & B shows the total effect upon the current when the transmitting instruments for A and B are

caused simultaneously to make and break the same circuit. The resultant effect depends very much upon the duration of the make rel--atively to the break. In Figure 1, the ratio is as 1 : 4; in Figure 2, as 1 : 2; and in Figure 3 the makes and breaks are of equal dura--tion.

The combined effect A, & B, Figure 3, is very nearly equivalent to a continuous current.

When many transmitting instruments of different rates of vibration are simultaneously making and breaking the same circuit, the current upon the main line becomes for all practical purposes continuous.

Next consider the effect when an undu--latory current is employed. Electrical un--dulations induced by the vibration of a body capable of inductive action can be represented graphically – without error – by the same sinu-soidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air; for, as above stated, the rate of oscilla--tion in the electrical current corresponds to the rate of vibration of the inducing body – that is to the pitch of the sound produced; the intensity of the current varies with the amplitude of the vibration, that

1983

is with the loudness of the sound; and the polarity of the current corresponds to the di--rection of the vibrating body – that is to the condensations, and rarefactions of air produced by the vibration. Hence the sinu-soidal curve A or B, Figure 4, represents graphically the elec--trical undulations induced in a circuit by the vibration of a body capable of induc--tive action.

The horizontal line *a d e f* &c represents the zero of current; the elevations *b b b* &c indicate impulses of positive electricity; the depressions *c c c* &c show impulses of negative elec--tricity; the vertical distance *b d* or *c f* of any portion of the curve from the zero--line expresses the intensity of the positive or negative impulse at the part observed, and the horizontal distance *a a* indi--cates the duration of the electrical oscillation. The vibrations represented by the sinu-soidal curves B and A, Figure 4, are in the ratio aforesaid of 4 : 5. That is four oscillations of B are made in the same time as five oscillations of A.

The combined effect of A and B when induced simultaneously on the same circuit is expressed by the curve A + B,

Figure 4, which is the Algebraical sum of the sinu-soidal curves A and B.

This curve A + B also indicates the actual motion of the air when the two musical notes considered are sounded simultaneously. Thus when electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced exact--ly analogous to that occasioned in the air by the vibration of the inducing bodies. Hence the coexistence upon a telegraphic circuit of electrical vibrations of different pitch is manifested, not by the obliteration of the vibratory charac--ter of the current, but by peculiarities in the shapes of the electrical undula--tions, or in other words, by peculiarities in the shapes of the curves which rep--resent those undulations.

There are many ways of producing undulatory currents of electricity, depen--dent for effect upon the vibrations or motion of bodies capable of induc--tive action. A few of the methods that may be employed I shall here specify. When a wire through which a continuous cur--rent of electricity is passing is caused to vibrate in the neighborhood of

1985

another wire – an undulatory current of elec--tricity is induced in the latter. When a cylinder upon which are arranged bar--magnets is made to rotate in front of the pole of an electro-magnet an undulatory current of electricity is induced in the coils of the electro-magnet.

Undulations are caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action: or by the vibration of the conducting wire itself in the neighborhood of such bodies. Electrical undulations may also be caused by alternately increasing and di--minishing the resistance of the circuit, or by alternately increasing and diminishing the power of the battery. The internal resistance of a battery is diminished by bringing the voltaic elements nearer together, and increased by placing them further apart. The recipro--cal vibration of the elements of a battery therefore occasions an undulatory action in the voltaic current. The external resistance may also be varied. For instance let mercury or some other liquid form part of a volta--ic circuit – then the more deeply the con--ducting wire is immersed in the mercury or other liquid the less resistance does the liquid

offer to the passage of the current. Hence the vibration of the conducting-wire in mercury or other liquid included in the circuit oc--casions undulations in the current. The vertical vibrations of the elements of a battery in the liquid in which they are immersed produces an undulatory action in the current by alternately increasing and diminishing the power of the battery.

In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for pro--ducing the effect. I prefer to employ for this purpose an electro-magnet A, Figure 5, having a coil upon only one of its legs *b*. A steel spring armature *c* is firmly clamped by one extremity to the uncovered leg *d*, of the magnet, and its free end is allowed to project above the pole of the covered leg. The armature *c* can be set in vibration in a variety of ways – one of which is by wind – and in vibrating it produces a musical note of a certain definite pitch.

When the instrument A is placed in a voltaic circuit g b e f g, the armature *c* be--comes magnetic and the polarity of its free end is opposed to that of the magnet

1 G481

under neath. So long as the armature *c* remains at rest, no effect is produced upon the volta--ic current, but the moment it is set in vibra--tion to produce its musical note a powerful inductive action takes place and electrical undulations traverse the circuit g b e f g. The vibratory current passing through the coil of the electro magnet *f* causes vibration in its armature *h* when the armatures *c h* of the two instruments A, I, are normally in unison with one another; but the armature *h* is unaffected by the passage of the undulatory current when the pitches of the two instruments are different.

A number of instruments may be placed upon a telegraphic circuit as in Figure 6. When the armature of any one of the instruments is set in vibration, all the other instruments upon the circuit which are in unison with it respond, but those which have normally a different rate of vibration remain silent. Thus if A, Figure 6 is set in vibration the armatures of A^1 and A^2 will vibrate also but all the others on the circuit will remain still. So if B^1 is caused to emit its musical note the instruments B, B^2, respond. They continue sounding so long as the mechanical vibration of B^1 is continued,

but become silent with the cessation of its motion.

The duration of the sound may be used to indicate the dot or dash of the Morse alphabet – and thus a telegraphic despatch may be indicated by alternately interrupting and renewing the sound.

When two or more instruments of different pitch are simultaneously caused to vibrate all the instruments of corresponding pitches upon the circuit are set in vibration, each responding to that one only of the transmitting instruments with which it is in unison. Thus the signals of A Fig--ure 6 are repeated by A^1 and A^2 but by no other instrument upon the circuit; the signals of B^2, by B and B^1; and the signals of c^1 by c and c^2 – whether A, B^2 and c^1 are successively or simultaneously caused to vibrate. Hence by these instruments two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another.

I desire here to remark that there are many other uses to which these instruments may be put – such as the simultaneous transmission of musical notes, differing in loudness as well as in pitch, and the

1981

telegraphic transmission of noises or sounds of any kind.

When the armature *c* Figure 5 is set in vibration the armature *h* responds not only in pitch, but in loudness. Thus when *c* vibrates with little amplitude a very soft musical note proceeds from *h*; and when *c* vibrates forcibly the amplitude of vibration of *h* is considerably increased, and the re--sulting sound becomes louder. So if A and B Figure 6 are sounded simultaneously (A loudly and B softly) the instruments A^1 and A^2 repeat loudly the signals of A, and B^1 B^2 repeat softly those of B.

One of the ways in which the armature *c* Figure 5, may be set in vibration has been stated above to be by wind. An--other mode is shown in Figure 7, where--by motion can be imparted to the ar--mature by the human voice or by means of a musical instrument.

The armature *c* Figure 7, is fastened loosely by one extremity to the uncov--ered leg *d* of the electro-magnet *b* and its other extremity is attached to the centre of a stretched membrane *a*. A cone A, is used to converge sound vibrations upon the membrane. When a sound is uttered in

the cone the membrane *a*, is set in vibration, the armature *c* is forced to partake of the motion, and thus electrical undulations are created upon the circuit E b e f g. These undulations are similar in form to the air vibrations caused by the sound – that is, they are represented graphically by similar curves.

The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A, is then heard to proceed from L.

In this specification the three words "oscillation" "vibration" and "undulation" are used synonymously ∧. By the term "Body capable of inductive action" I mean a body which when in motion produces dynamical electricity. I include in the category of bodies capable of inductive action – brass, copper and other metals, as well as iron and steel.

Inser per Amdt B. Feb 29 '76

Having described my invention what I claim and desire to secure by letters patent as follows: —

1. A system of telegraphy in which the receiver is set in vibration by the employment of undulatory currents of electricity substantially as set forth.

Caveat 48.

2. The combination substantially as set forth of a

1591

permanent magnet or other body capable of induc-
-tive action with a closed circuit so that the
vibration of the one shall occasion electrical
undulations in the other or in itself – and this
I claim, whether the permanent magnet be set in
vibration in the neighborhood of the conducting wire
forming the circuit; or whether the conducting wire
be set in vibration in the neighborhood of the
permanent magnet; or whether the conducting wire
and the permanent magnet both simultaneously
be set in vibration in each others neighborhood.

3. The method of producing undulations in a con-
-tinuous voltaic current by the vibration or
motion of bodies capable of inductive action;
or by the vibration or motion of the con-
-ducting wire itself in the neighborhood of
such bodies as set forth.

aveat 48.

4. The method of producing undulations in
a continuous voltaic circuit by [alternately] *gradually*
increasing and diminishing the resistance of
the circuit; or by [alternately] *gradually* increasing and
diminishing the power of the battery as set forth.

rase & insert
per Amdt C,
Febr 29 '76

5. The method of and apparatus for transmitting
vocal or other sounds telegraphically as herein
described by causing electrical undulations
similar in form to the vibrations of the
air accompanying the said vocal or other
sounds substantially as set forth.

Caveat 48.

199/12

In testimony whereof I have hereunto signed my name this 20th day of January A.D. 1876.

Witnesses

Thomas E. Barry — Alex. Graham Bell

P D Richards.

State of Massachusetts :

:

Suffolk County : ss

Alexander Graham Bell – the above named petitioner being duly sworn deposes and says that he verily believes himself to be the original and first inventor of the Im-provements in Telegraphy ————————

————————————————————

described and claimed in the foregoing specifi-cation; that he does not know and does not believe that the same was ever before known or used; and that he is a native of Great Britian and has declared his intention of becoming a citizen of the United States.

Thomas E. Barry
P D Richards. } witnesses — Alex. Graham Bell

Sworn to and subscribed before me this 20th day of January A. D. 1876

Thomas E. Barry

(seal)

Notary Public

1993

Copy sent
Feb. 19
S. R. A.

EXAMINER'S ROOM, No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb'y 19, 1876.

A. G. BELL,
Care POLLOK & BAILEY, Present.

Telegraphy FEB'Y 14, 1876.

In this case it is found that the 1st, 4th and 5th clauses of claim relate to matters described in a pending caveat.

The caveator has been notified to complete and this app'n is suspended for 90 days, as required by law.

Z. F. WILBER, Ex'r.

[*Endorsed*] "$\frac{158}{68}$ 1 Office Letter Febr. 19' 1876."

IN THE MATTER OF THE APPLICATION OF A. GRAHAM BELL FOR IMPTS. IN TELEGRAPHY, FILED FEBY. 14, '76.

HON. COMM'R OF PATENTS:

Sir, — In this matter we beg to acknowledge receipt of official letter, notifying us of the suspension of our application for completion of an interfering caveat.

We respectfully request, before it is concluded to suspend our application for 3 months, that you determine whether or not our application was not filed prior to the caveat in question.

We have inquired the date of filing of the caveat (inasmuch as we are entitled to the knowledge) and find it to be February 14, 1876, the same day on which our application was filed. If our application was filed earlier in the day than was the caveat, then there is no warrant for the action taken by the Office.

We suggest that an examination of the books in the Examiner's, Mr. Moore's and the chief clerk's rooms, be made with a view of determining this question.

We can say that our application was filed early in the day on Feb'y 14, and at our request was on the same day sent to the Examiner;

we also call attention to the fact that our client's oath of invention is dated Jan'y 20, '76.

Respectfully,

POLLOK & BAILEY, Atty's.

[*Endorsed*] "$\frac{158}{58}$ 2 Appt's Protest Feb'y 24th 1876."

[*The following "reference to Com'r," "order of Com'r" and minute of Wilber, Ex'r, were written on the same paper with the foregoing "Protest."*]

"EXAMINER'S ROOM 118, Feb'y 24, 1876.

"Respectfully referred to the Hon. Commr. for instructions. The regular practice in the office has been to determine dates of filing by *days alone*, and in accordance with such practice I suspended the application herein referred to on a/c of a caveat, the application and caveat being filed upon the same day, viz., Feb'y 14, 1876.

"In view of the practice above noted, I have paid no attention to the alleged difference between the times of the filings on same day.

"Respectfully submitted,

"Z. F. WILBER, Ex'r."

"The application in order to become liable to suspension to await the completion of his application by a caveator must have been filed "within the year" of the life of the caveat. Ordinarily the day of filing is not computed, and is considered *punctum temporis*. Yet where justice requires it, the exact time in the day when an act was done may be shown by proof. Kent's Comm. 95, n. The Examiner will be guided by this rule in the present case, and if the record shows that the application was filed earlier in the day, then the caveat should be disregarded, and otherwise not.

"ELLIS SPEAR,

"Act'g Com'r.

"25, 2, '76."

"EX'R'S ROOM 118, Feb'y 25, 1876.

"The cash blotter in the chief clerk's room shows conclusively that the application was filed some time earlier on the 14th than the caveat.

"The app'n was received also in 118 by noon of the 14th, the caveat not until the 15th.

"Z. F. WILBER, Ex'r."

AMENDMENT.

1995

Copy sent,
Febr. 25.
S. R. A.

EXAMINER'S ROOM, No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb'y 25, 1876.

A. G. BELL,
Care POLLOK & BAILEY, Present.

Telegraphy, FEB'Y 14, 1876.

The suspension of this application having been declared under a misapprehension of appt.'s rights, is withdrawn.

Z. F. WILBER, Ex'r.

[*Endorsed*] "$\frac{168}{58}$ 3 Office Letter Febr. 25, 1876."

IN THE MATTER OF THE APPLICATION OF A. GRAHAM BELL, FOR A PATENT FOR IMPROVEMENTS IN TELEGRAPHY, FILED FEB'Y 14, 1876.

In this matter amend the specification as follows: —

Page 2, erase from line 19 to line 24 inclusive, and substitute therefor the following: —

In a pending application for Letters Patent, filed in the U. S. Patent Office February 25, 1875, I have described two ways of producing the intermittent current, the one by actual make and break of contact, the other by alternately increasing and diminishing the intensity of the current, without actually breaking the circuit; the current produced by the latter method I shall term, for distinction sake, a pulsatory current. Amdt A. Febr 29 '76

My present invention consists in the employment of a vibratory or undulatory current of electricity, in contradistinction to a merely intermittent or pulsatory current, and of a method of and apparatus for producing electrical undulations upon the line wire.

The distinction between an undulatory and a pulsatory current will be understood by considering that electrical pulsations are caused by sudden or instantaneous changes of intensity, and that electrical undulations result from *gradual* changes of intensity exactly analogous to the changes in the density of air occasioned by

1996

simple pendulous vibrations. The electrical movement, like the aerial motion, can be represented by a sinusoidal curve, or by the resultant of several sinusoidal curves.

Intermittent or pulsatory and undulatory currents may be of two kinds, accordingly as the successive impulses have all the same polarity, or are alternately positive and negative.

Page 13, line 15, after "synonymously" insert

Amdt B, Feb 29 '76 and in contradistinction to the terms "intermittent" and "pulsatory."

Amdt C, Febr 29 '76 In the 4th claim, erase the word "alternately" wherever it occurs, and substitute therefor the word "gradually."

POLLOK & BAILEY,
Atty's for A. GRAHAM BELL.

[*Endorsed*] "$\frac{158}{58}$ 4 Amendts A — C Febr. 29th 1876."

Copied
Mar. 26, '76.
Room No. 118. [No. 14.] [Interference.]

All communications should be addressed to the Commissioner of Patents.

INTERFERENCE A.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

$\frac{158}{58}$ WASHINGTON, D. C., Mar. 26, 1878.

Also copy to

A. G. BELL,
Care A. POLLOK, Present.

GARDINER G. HUBBARD,
Cambridge, Mass.

Please find below a copy of a communication from the Examiner concerning your patent No. 174,465, dated Mar. 7, 1876, for Telegraphy.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

21 1997

Your case above referred to is adjudged to interfere with the applications and patents named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is "The hereinbefore described art of transmitting and reproducing at a distance sonorous [words] *waves* or vibrations of any description, which consists in increasing and decreasing the strength of an electric current traversing a circuit in such a manner as to produce in said circuit a series of electrical waves or vibrations precisely corresponding in their intervals of succession and relative amplitudes to the sonorous waves which are to be reproduced at the receiving station or stations, so that oral conversations or sounds of any description may be telegraphically transmitted." (Gray's 1st claim.)

This is substantially the method specified in Bell's 5th claim, and is described in the applications of Edison, Berliner, Richmond, Dolbear and Holcombe.

PARTIES TO INTERFERENCE.

Wm. L. Voelker, filed May 19, 1879.
R. D. O. Smith, included Dec. 29, 1879.

Elisha Gray, App'n filed Oct. 29, 1877. (No. 1). Atty's of Record, Baldwin, Hopkins and Peyton, Washington, D. C.

Thos. A. Edison, App'n filed Apr. 27, 1877. (Case 130.) Att'y of Record, L. W. Serrell, Box 4,689, New York City.

Emile Berliner, App'n filed June 4, 1877. Att'y of Record, James L. Norris, Washington, D. C.

Geo. B. Richmond, App'n filed Aug. 24, 1877. Att'y of Record, George W. Dyer, Washington, D. C.

A. G. Holcombe, App'n filed Jan. 28, 1878. Att'y of Record, Moses G. Farmer, Torpedo Station, Newport, R. I.

A. E. Dolbear, App'n filed Oct. 31, 1877. (A.) Att'y of Record, Frank L. Pope, Elizabeth, N. J., Jas. L. Norris, Asso. Att'y, Wash., D. C.

H. C. TOWNSEND, Ex'r. 450

[*Endorsed*] "$\frac{158}{58}$ 6 Intf. "A" Mar. 26, 1878."

1998

Copy,
Mar. 25, 1878.
P. W. P.
Room No. 118. [No. 14.] [Interference.]

All communications should be addressed to the Commissioner of Patents.

INTERFERENCE B.

158
58

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., March 26, 1878.

Also copy to

ALEXR. G. BELL,
Care A. POLLOK, Present.

GARDINER G. HUBBARD,
Cambridge, Mass.

Please find below a copy of a communication from the Examiner, concerning your patent 174,465, dated March 7, 76. "Telegraphy."

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is the hereinbefore described improvement in the art of transmitting vocal sounds or spoken words telegraphically, which consists in throwing upon the line through the medium of a varying resistance electric impulses corresponding to the vibrations of a diaphragm operated by the movements of the air produced by a spoken word. (Gray's 2nd claim.)

1699

This is substantially described in the applications of Gray, Edison, Berliner and Richmond.

The parties to the interference are: Elisha Gray, app'n filed Oct. 29, '77; Attorneys, Baldwin, Hopkins & Peyton, Washington, D. C. T. A. Edison, app'n filed April 27, '77 (case 130); Att'y, L. W. Serrell, Box 4,689, N. Y. City. Emile Berliner, app'n filed June 4, '77; Att'y, Jas. L. Norris, Washington, D. C. Geo. B. Richmond, app'n filed Aug. 24, '77; Att'y, Geo. W. Dyer, Washington, D. C.

Wm. L. Voelker, filed May 19, 1879.
R. D. O. Smith, included Dec. 29, 1879.

H. C. TOWNSEND, Exr.

[*Endorsed*] "$\frac{158}{58}$ 7 Intf B. Mch. 26 '78."

Two copies.
Mar. 26, 1878.
P. W. P.
Room No. 118. [No. 14.] [Interference.]

All communications should be addressed to the Commissioner of Patents.

$\frac{158}{58}$

PATENT 174,465.—INTERFERENCE C.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., Mar. 26, 1878.

Also copy to

ALEX. G. BELL,
Care A. POLLOK, Present.

GARDINER G. HUBBARD,
Cambridge, Mass.

Please find below a copy of a communication from the Examiner concerning your patent No. 174,465, dated Mar. 7, '76.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is: 1st. The transmitter, consisting of the combination in an electric circuit of a diaphragm and a liquid or equivalent substance of high resistance, whereby the variations of the diaphragm cause variations in the resistance of the electric circuit, and consequently in the strength of current traversing said circuit. (Gray's 1st claim.)

This is described in the applications of Richmond and Edison and patent of Bell.

2d. In a telegraph instrument operated by sound, the combination with the diaphragm of two or more electrodes placed in electrolytic liquid and operating to increase and decrease the resistance of the electric circuit, by the movement derived from the diaphragm. (Edison's 1st claim.)

This is described in the applications of Richmond and Gray, and is substantially suggested in Bell's patent.

The parties to this interference are: Elisha Gray, Dec. 4, '77 (No. 2); Baldwin, Hopkins & Peyton, Washington, D. C., Att'ys of record. G. B. Richmond, app'n filed Aug. 24, '77; G. W. Dyer, Washington, D. C., Att'y. T. A. Edison, app'n filed Sept. 5, '77 (case 144); L. W. Serrell, Box 4,689, New York City, Att'y.

H. C. TOWNSEND, Ex'r.

[*Endorsed*] "$\frac{158}{58}$ 8 Intf C, Mch 26, 78."

Copy, Mar. 26, 1878. Room No. 118. [No. 14]. [Interference.]
P. W. P.

All communications should be addressed to the Commissioner of Patents.

$\frac{158}{58}$

PATENT 174,465.—INTERFERENCE E.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., Mar. 26, 1878.

Copy to care

ALEX. G. BELL,
Care A. POLLOK, Present.

GARDINER G. HUBBARD,
Cambridge, Mass.

Please find below a copy of a communication from the Examiner concerning your patent, No. 174,465, dated March 7, '76.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is, In an acoustic telegraph an armature plate, the electro-magnet for the same, and a closed circuit passing from the helix of such electro-magnet to the source of undulatory electric energy.

This is the subject matter of Edison's 3d claim, and is substantially described in the other applications and the patent involved.

The parties to this interference are: —

T. A. Edison's app'n filed Dec. 12, '77 (case 145);

L. W. Serrell, Box 4,689, N. Y. City, Attorney.

A. E. Dolbear, app'n filed Oct. 31, '77;

F. L. Pope, Elizabeth, N. J., Att'y of Record, and Jas. L. Norris, Washington, D. C., Associate.

Geo. B. Richmond, app'n filed Aug. 24, '77;

G. W. Dyer, Washington, D. C., Att'y.

Elisha Gray, app'n filed Dec. 4, '77 (No. 3);
Baldwin, Hopkins & Peyton, Washington, D. C., Att'ys.
A. G. Holcombe, app'n filed Jan. 20, '78;
M. G. Farmer, Torpedo Station, Newport, R. I., Att'y.
H. C. TOWNSEND, Ex'r. 350.

[*Endorsed*] "$\frac{158}{58}$ 9 Intf "E," Mar. 26, 78."

Copy sent
March 26, 1878.
L. S. R.
Room No. 118. [No. 14] [Interference.]

All communications should be addressed to the Commissioner of Patents.

$\frac{158}{58}$

PATENT 174,465. — INTERFERENCE F.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., March 26, 1878.

Also copy to

A. G. BELL, Care A. POLLOK, Present.

GARDINER G. HUBBARD, Cambridge, Mass.

Please find below a copy of a communication from the Examiner, concerning your patent, No. 174,465, dated Mar. 7, '76 Telegraphy.

Very respectfully,
ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is a telephonic transmitter, consisting of a coil of wire, one or more magnets, and

a disc or diaphragm, so arranged relative to each other that a motion of the diaphragm shall induce in the coil of wire an electric motive force in virtue of the presence of the magnet or magnets.

This is substantially Holcombe's 1st claim, and is described and shown in applications of Dolbear and Gray, and patent of Bell.

The parties to this interference are:—

A. G. Holcombe, app'n filed Jan. 28, '78;

M. G. Farmer, Torpedo Station, Newport, R. I., Attorney.

A. E. Dolbear, app'n filed Oct. 31, '77; F. L. Pope, Elizabeth, N. J., Att'y, and J. L. Norris, Washington, D. C., Associate.

Elisha Gray, app'n filed Oct. 29, '77 (No. 1); Baldwin, Hopkins & Peyton, Washington, D. C., Att'ys.

350 H. C. TOWNSEND, Ex'r.

[*Endorsed*] "$\frac{158}{68}$ 10 Intf. F. Mar. 26th 1878."

Copy sent
Mar. 26, 1878.
L. S. R.
Room No. 118. [No. 14.] [Interference.]

All communications should be addressed to the Commissioner of Patents.

INTERFERENCE G.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

$\frac{158}{68}$

WASHINGTON, D. C., Mch. 26, 1878.

Also copy to

A. G. BELL, Care A. POLLOK, Present.

GARDINER G. HUBBARD, Cambridge, Mass.

Please find below a copy of a communication from the Examiner concerning your patent for "Telegraphy," No. 174,465, dated Mar. 7, 1876.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

2007 28

Your case above referred to is adjudged to interfere with applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is A telephonic receiver, consisting of the combination in an electric circuit of a magnet and a dia phragm supported and arranged in close proximity thereto, whereby sounds thrown upon the line may be reproduced accurately as to pitch and quality (substantially Gray's claim).

This is substantially covered by Holcombe's 2nd claim, and is described or shown in the applications of Richmond, Dolbear, Edison and McDonough, and in patent of Bell.

PARTIES TO INTERFERENCE.

Elisha Gray, App'n filed Dec. 4, 1877 (No. 3); Baldwin, Hopkins & Peyton, Washington, D. C., Att'ys of Record.

George B. Richmond, App'n filed Aug. 24, 1877; G. W. Dyer, Washington, D. C., Att'y of Record.

A. E. Dolbear, App'n filed Oct. 31, 1877; F. L. Pope, Elizabeth, N. J., Att'y of Record; J. L. Norris, Washington, D. C., Asso. Att'y.

T. A. Edison, App'n filed Dec. 24, 1877; (No. 148), L. W. Serrell, Box 4,689, New York City, Att'y of Record.

A. G. Holcombe, App'n filed Jan. 28, 1878; Moses G. Farmer, Torpedo Station, Newport, R. I., Att'y of Record.

James W. McDonough, App'n filed Apr. 10, 1876; Gridley and Sherburne, Chicago, Ill., Att'y of Record.

A. G. Bell, Pat. No. 174,465, dated Mar. 7, 1876; A. Pollok, Wash'n, D. C., Att'y of Record.

H. C. TOWNSEND, Ex'r. 450

[*Endorsed*] "$\frac{158}{684}$ 11 Intf. G. Mch. 26, 78."

Copy made
Mar. 26, 1878.
J. H. M.
Room No. 118. [No. 14.] [Interference.]

All communications should be addressed to the Commissioner of Patents.

158
58

INTERFERENCE H.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., Mch. 26, 1878.

Also copy to

A. G. BELL, Care A. POLLOK, Present.

GARDINER G. HUBBARD, Cambridge, Mass.

Please find below a copy of a communication from the Examiner concerning your Pat. No. 174,465, dated Mar. 7, 1876,

"Telegraphy."

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is The combination in one circuit of two or more coils of wire, two or more magnets, and two or more discs or diaphragms, so arranged relatively to each other that if one of the discs or diaphrams be put in motion by the voice, by a current of air or otherwise, it shall induce a transient current of electricity in its associated coil, which current shall actuate the other discs or diaphrams in virtue of the coils and magnets associated with them. (Holcombe's 3rd claim.)

This is described and shown in applications of Dolbear and Gray, and patent of Bell.

2006

PARTIES TO INTERFERENCE.

A. G. Holcombe, App'n filed Jan. 28, 1878;

Moses G. Farmer, Torpedo Station, Newport, R. I., Att'y of Record.

Elisha Gray, App'n filed Oct. 29, 1877 (No. 1);

Baldwin, Hopkins & Peyton, Washington, D. C., Att'ys of Record.

A. E. Dolbear, App'n filed Oct. 31, 1877;

F. L. Pope, Elizabeth, N. J., Att'y of Record;

J. L. Norris, Washington, D. C., Asso. Att'y.

H. C. TOWNSEND, Ex'r. 400.

[*Endorsed*] "$\frac{158}{58}$ 12 Intf. H. Mch, 26, 78."

Copy,
Mar. 25, 1878. [No. 14.] [Interference.]
P. W. P. Patent 174,465.
Room No. 118.

INTERFERENCE L.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

All communications should be addressed to the Commissioner of Patents.

$\frac{158}{58}$

WASHINGTON, D. C., Mar. 26, 1878.

Also copy to

ALEXR. G. BELL, Care A. POLLOK, Present.— GARDINER G. HUBBARD. Cambridge, Mass.

Please find below a copy of a communication from the Examiner concerning your patent, No. 174,465, dated Mar. 7, '76. Telegraphy.

Very respectfully,
ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelepe. Ths subject matter involved in the interference is: 1st. The combination in an acoustic telegraph of an electro-magnet, and a polarized armature formed of a plate of iron, steel or other material capable of inductive action, and a resonant tube or case. (Edison's 1st claim.)

2d. The combination in an acoustic telegraph of an armature plate polarized by induction, a resonant case or tube, and an electro-magnet and circuit connections, whereby reverse currents are caused to act in the electro-magnet with varying intensity proportionate to the electric waves sent from the transmitting station. (Edison's 2nd claim.)

This subject matter is described and shown in the applications of Edison and Gray.

The parties to this interference are: T. A. Edison, app'n filed Dec. 13, '77 (case 145); L. W. Serrell, box 4,689, N. Y. City, Att'y of Record. Elisha Gray, app'n filed Jan. 17, '78; Att'ys, Baldwin' Hopkins & Peyton, Washington, D. C.

H. C. TOWNSEND, Ex'r. 400.

[*Endorsed*] "$\frac{158}{68}$ 13 Intf. L. Mar. 26, 1878."

Copied.
Room No. 3.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., Dec. 26. 1878.

BEFORE THE PRIMARY EXAMINER.

IN RE INTERFERENCE, BELL VS. GRAY ET AL.

Subject Matter: Telephony.

Cases from A to L.

A. G. BELL,
Care A. POLLOK, Present.

ELISHA GRAY,
Care BALDWIN, HOPKINS & PEYTON, Present.

200

A. G. HOLCOMBE,
Care M. G. FARMER,
Torpedo Station, Newport, R. I.

AMOS E. DOLBEAR,
Care JAS. L. NORRIS, Present.

GEO. B. RICHMOND,
Care GEO. W. DYER, Present.

EMILE BERLINER,
Care A. POLLOK, Present.

THOS. A. EDISON,
Care L. W. SERRELL,
P. O. Box, 4,689, N. Y. City.

JAS. W. McDONOUGH,
Care GRIDLEY & SHERBURNE,
Chicago, Ill.

The motion made on behalf of Bell to dissolve and reform these interferences is denied by the Primary Examiner.

In the absence of any appeal from this decision within one week from date, these cases will be returned to the Examiner of interferences, and proceeding looking to the determination of the question of priority will be resumed.

200 H. C. TOWNSEND, Ex'r.

Copied.
Room No. 118

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

WASHINGTON, D. C., Dec. 30, 1878.

BEFORE THE PRIMARY EXAMINER.

IN RE INTERFERENCE, BELL VS. GRAY ET AL.

Subject Matter, Telephony.

Cases, A to L.

A. G. BELL,
Care A. POLLOK, Present.

ELISHA GRAY,
Care BALDWIN, HOPKINS,
& PEYTON, Present.

2809

A. G. HOLCOMBE,
Care M. G. FARMER,
Torpedo Station, Newport, R. I.

AMOS E. DOLBEAR,
Care JAS. L. NORRIS, Present.

GEO. B. RICHMOND,
Care GEO. W. DYER, Present.

EMILE BERLINER,
Care A. POLLOK, Present.

THOS. A. EDISON,
Care L. W. SERRELL,
P. O. Box, 4,689, N. Y. City.

JAS. W. McDONOUGH,
Care GRIDLEY & SHERBURNE,
Chicago, Ill.

The limit of appeal from the decision of the Primary Examiner upon Bell's motion is extended to Jan'y 4th, 1879.

H. C. TOWNSEND, Ex'r.

Room No. 118

All communications should be addressed to the Commissioner of Patents.

Copied.

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C., Dec 29, 1879.

A. G. BELL
Care A. POLLOK PRESENT.
Telegraphy Patent No. 174465
Mar 7, 1876.

The application of Wm. L. Voelker of Morton, Pa., filed May 19, 1879 Atty-of-record R. D. O. Smith Present, has been this day included in the interference designated "A", declared Mar. 26, 1878, between the applications of Way (No 1), Edison (130), Berliner Richmond Dolbear, Holcombe and patent of Bell No 174465.

The application of Voelker substantially covers the invention in controversy. Until Jan'y 19, 1880, has been allowed for filing the preliminary statement.

H. C. TOWNSEND, Ex'r. 150

[*Endorsed*] "$\frac{158}{58}$ 14 Office Letter Dec. 29, 1879."

2010

Room No. 118.

All communications should be addressed to the Commissioner of Patents.

Copied.

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C., Dec. 29, 1879.

A. G. BELL

Care A. POLLOK, Present.

Telegraphy Patent No 174465,

Mar 7, 1876.

The application of Wm. L. Voelker of Morton Pa., filed May 19, 1879, Atty-of record R. D. O. Smith, Present, has been this day included in the interference designated "B", declared Mar. 26, 1878, between the applications of Gray (No 1) Edison (130) Berliner, Richmond & Bell patent No 174465.

The invention in controversy is substantially claimed by Voelker claim 1. Until Jan'y 19, 1880, has been allowed for filing the preliminary statement.

H. C. TOWNSEND, Ex'r.

150

[*Endorsed*] "$\frac{158}{58}$ 15 Office Letter, Dec. 29, 1879."

MEMORANDUM OF FEE PAID AT U. S. PATENT OFFICE.

Inventor,
A. G. BELL.
Patent to be issued to

Invention.
Telegraphy.
Date of Payment,

Mch. 4th, '76.
Final
Fee,
$20.
Solicitors,
POLLOK & BAILEY,
Present.

FILE WRAPPER. 174,465

1876. 158/58

No. 174,465.

ALEXANDER GRAHAM BELL.

Of Salem,
County of
State of Mass.

TELEGRAPHY.

Rec'd Feb. 14, 1876.
Petition, " "
Affidavit, " "
Specification, " "
1 Drawing 2 sheets, " "
Model.
Cert. dep.
1 Cash $15. Feb. 14, 1876.
Add'l Fee Cert.
1 " " Cash $20. Mch. 4, 1876.
Examined March 3d, 1874, Wilber.
2 Issue March 3, '76, Knight, M.
4 Patented Mch. 7, 1876.
Circular Mch 3, 1876.

POLLOK & BAILEY,
Present.

1876.

CONTENTS.

Application, 1 paper.
1 Letter, Feb. 19, 1876.
2 Appt's Protest, Feb'y 24, 1876.
3 Office Letter " 25, "
4 Amend^{ts}. A. C., Feb. 29, '76.
5 Briefed March 3d, 1876.

A. 6 Int'f. $\times \frac{116}{73}, \frac{72}{64}, \frac{86}{12}, \frac{104}{58}, \frac{118}{1}, \frac{135}{90}$. Mar. 26, 1878.
B. 7 Int'f. $\times \frac{116}{73}, \frac{72}{64}, \frac{86}{12}, \frac{104}{58}$. Mar. 26, 1878.
C. 8 Int'f. $\times \frac{116}{72}, \frac{104}{58}, \frac{107}{15}$. Mar. 26, 1878.

E.	9	Int'f. $\times \frac{126}{48}, \frac{118}{1}, \frac{104}{58}, \frac{116}{71}, \frac{135}{90}$.	Mar. 26, 1878.
F.	10	Int'f. $\times \frac{135}{90}, \frac{118}{1}, \frac{116}{73}$.	Mar. 26, 1878.
G.	11	Int'f. $\times \frac{116}{71}, \frac{104}{58}, \frac{118}{1}, \frac{128}{85}, \frac{135}{90}, \frac{176}{32}$.	Mar. 26, 1878.
H.	12	Int'f. $\times \frac{135}{90}, \frac{118}{1}, \frac{116}{73}$.	Mar. 26, 1878.
L.	13	Int'f. $\times \frac{126}{48}, \frac{133}{54}$.	Mar. 26, 1878.
	14	Letter	Dec. 29, 1879.
	15	Letter	Dec. 29, 1879.
	16		
	17		
	18		

TITLE.

Improvement in Telegraphy.

201?

DEFENDANT'S EXHIBITS.

Contents.

	PAGE
Order amending answers	1
Stipulation as to testimony	2
List of Defendant's Exhibits 1 to 61	4–14
Schellen translation	15
Extract from "The Electric Telegraph"	18
Electricity and magnetism by Jenkin	20
Hassler's description of Reis	22
Reis' lecture	24
Reis-Legat article	31
Pisko's description of Reis	38
Ferguson's description of Reis	48
The Telegrapher	50
"The Manufacturer and Builder"	51
Baile's article	54
Böttger's account of Reis' improved apparatus	57
Cosmos description of Reis	58
Koenig's description of Reis	62
Du Moncel's bourseul	63
Didaskalia bourseul article	65
Extracts from Didaskalia	67
Report of Reis' lecture	69
Reis' exhibition of 1861	71
Muller's-Pouillet's description of Reis	73
Böttger's article	76
Dr. Clemens' publication	79
Industrial gazette	80
Gartenlaube-Reis improved apparatus	84
Polytechnisches Centralblatt	89
Reis' letter to Ladd	90
Tagesblatt der 39 Versammlung Deutsche Naturforscher	93
Kuhn's description of Reis	94
Albert's catalogue of 1873	100
"Zeitschrift Deutsch-Oesterreichischen Telegraphen Vereins"	101
Journal of the Society of Architects and Engineers for the Kingdom of Hanover	102

PAGE
Dublin Medical Press 103
Cosmos [Moigno] 104
Scientific American Supplement, Feb. 5, 1876 105
Dr. Van Der Weyde's second article in Scientific American, March 4, 1876 114
Extract from Electric Telegraph 118
Annual Report of American Association, etc 122
Extract from the Telegraphic Journal, &c 123
Edison relay-magnet patent 129
Gray's animal tissue patent 131
Gray's tune bar receiver patent 136
Gray's magnet receiver patent 139
Gray's magnet receiver reissue—art division 143
Gray's magnet receiver reissue—apparatus division 148
Gray's Caveat 2 153
Gray's sounding box receiver patent 163
Gray's closed circuit patent 166
Patent to Cromwell F. Varley 171
Johnson patent, Gray's magnetic receiver 178
Wheatstone and Cooke patent 184
Gray's organ-pipe transmitter patent 232
Gray's reed transmitter 234
Lockwood and Bartlett's patent for transmitter 238
Lockwood and Bartlett's patent for receiver 242
Deposition of Wm. M. Goodridge 245
Deposition of Wm. M. Goodridge, recalled 286
Deposition of Elisha Gray 296
Deposition of Elisha Gray, recalled 339
Magnet receiver application 346
Gray's printer patent 371
Gray's common receiver patent 385
Gray's revolving drum telephone patent 390
Gray's speaking telephone, art application 394
Gray's liquid transmitter application 412
Gray's concave diaphragm apparatus 422
Gray's first single tone transmitter 437
Animal tissue violin receiver 438
Animal tissue revolving plate receiver 439
Paper drum receiver 440
Gray's concave metallic diaphragm magnet receiver 441

PAGE

Gray's two-octave transmitter 441½
Gray's closed circuit apparatus 442
Gray's wooden sounding box receiver 443
Diaphragm box receiver 444
Gray's mechanical transmitter 445
Gray's multiple transmitter of 1875 446
Gray's two-tone transmitter 447
Tin-plate receiver 447
Gray's resonant box magnet receiver 447
McDonough evidence 448
Stipulation of attorneys as to introduction of evidence 507
Gray's patent of Feb. 15, 1876 510
Patent of Alfred G. Holcomb, May 15, 1860 513
Patent of William Thompson 517
Patent of Alfred G. Holcomb, June 4, 1881 536
Improvement in magnets, from "Scientific American" 539
Prof. Blake's compound harmonic curves 541
Holcomb affidavit 543
Van Der Weyde "Tribune" article 546
Van Der Weyde "Polytechnic Record" 548
Van Der Weyde affidavit 549
Smithsonian Institute, No. 1 553
Smithsonian Institute, No. 2 554
Smithsonian Institute, No. 3 555
Smithsonian Institute, No. 4 557
Didaskalia, No. 130, May 11, 1862 559
Didaskalia, No. 133, May 14, 1862 560
The Book of Inventions, Trades, &c., Leipsic 562
"Aus der Natur" 564
British letters patent to Henry Johnson 570
Disclaimer and memorandum of alteration of Morgan Brown 578
Specification of D. E. Hughes 602
Specification of Joseph C. J. Kennedy 611
Translation Reis article 623
The Telephone, by Alex. G. Bell 630
French patent 661
Smithsonian Reis transmitter, views 1 and 2 672
Smithsonian Reis receiver, views 1 and 2 ..... 672½
Original German article from "Aus der Natur" 673

2016

At a Stated Term of the Circuit Court of the United States for the Southern District of New York, held at the Court House, Post-Office Building, in the City of New York, on the 13th day of February, 1885.

Present—Hon. Wm. J. Wallace, Justice.

The American Bell Telephone Company et al.

against

The Molecular Telephone Company et al.

On reading and filing the affidavits of Wheeler H. Peckham and of George Bell, hereto annexed, and after hearing Mr. Peckham for the motion and Mr. Dickerson in open Court consenting, it is

Ordered, that the motion of defendants to amend the answers herein in the manner asked in the notice of motion be, and the same is hereby, granted.

Ordered further, that said answers be, and the same are hereby amended *nunc pro tunc* as of the date of filing the same by inserting on the 6th page, folio 31, immediately after the words, "Cambridge, Mass," where it secondly occurs, and before the words, "and also," the following words, "George W. Beardslee, of Brooklyn, New York, at College Point, Long Island, New York, and at Brooklyn, New York," and by inserting the same words on page fourteen of said answer opposite folio fifty-four immediately before the words "and also by numerous."

Wm. J. Wallace.

(A copy.)

[seal.]

Timothy Griffith,

Clerk.

E. L. M.

3017

CIRCUIT COURT OF THE UNITED STATES,

SOUTHERN DISTRICT OF NEW YORK.

IN EQUITY.

AMERICAN BELL TELEPHONE COMPANY ET AL.

AGAINST

MOLECULAR TELEPHONE COMPANY ET AL.

Stipulation.

It is hereby stipulated and agreed by and between the respective parties to the above entitled cause, as follows, to wit:

1. The defendants herein may put in evidence the copy of the depositions of William M. Goodridge and Elisha Gray, respectively, and of the documentary exhibits referred to therein, contained in the printed record of the case of Bell Telephone Company *et al.* vs. Peter A. Dowd, formerly pending in the Circuit Court of the United States within the District of Massachusetts; and the complainants herein may put in evidence the copy of any other deposition or depositions, and of the documentary exhibits referred to therein contained in the same printed record, and relating to or bearing upon the testimony of the said William M. Goodridge and Elisha Gray, and such copies so put in evidence shall have the same force and effect as if the said depositions had been originally taken, sworn to and filed in this cause.

2. The copies or translations of the publications designated upon pages 529, 530 and 530½, and printed upon pages 531 to 623, inclusive, of the record in the case of the American Bell Telephone Company vs. Amos E. Dolbear *et al.*, formerly pending in the Circuit Court of the United States, within the District of Massachusetts, may also be put in evidence in this cause with the same force and effect as though the originals had been produced and duly proved herein. The copies of such of the said publications as are mentioned in the defendants' answer in this cause shall be deemed to have been put in evidence by the defendants, and the remainder shall be deemed to have been put in evidence by the complainants,

but either party shall be at liberty to take further evidence, if need be, in relation to the meaning of the originals or any part thereof in a foreign language from which the said translations have been made.

3. The defendants and the complainants herein respectively may also put in evidence copies of any caveats, patents, applications for patents or other documentary matter, not embraced in the publications already hereinbefore referred to, contained in the printed records of the following cases formerly pending in the Circuit Court of the United States, within the District of Massachusetts, to wit: Bell Telephone Company *et al.* vs. Peter A. Dowd; American Bell Telephone Company vs. Albert Spencer *et al.*; and American Bell Telephone Company vs. Amos E. Dolbear *et al.*; and such copies, so put in evidence, shall have the same force and effect in this cause as though the originals thereof had been produced and duly proved herein.

4. The defendants herein may also put in evidence copies, duly certified from the Patent Office, of the testimony taken on behalf of James W. McDonough, and of the documents, drawings and models referred to therein as exhibits in the interference designated "G," declared March 26, 1878, between him, Elisha Gray, Amos E. Dolbear, Alexander Graham Bell, George B. Richmond, Thomas A. Edison and Emile Berliner, and such copies, so put in evidence, shall have the same force and effect as if the said testimony had been originally taken, sworn to and filed in this cause.

5. All the evidence taken and hereafter to be taken in the case of the American Bell Telephone Company *et al.* vs. The People's Telephone Company *et al.*, pending in the Circuit Court of the United States, within the Southern District of New York, shall be considered and treated as if the evidence for complainants and defendants respectively in that cause had been taken, sworn to and filed on behalf of the complainants and defendants respectively in this cause, and the printed record in that cause shall constitute part of the record upon which this cause shall be presented for judicial determination at final hearing.

GEO. L. ROBERTS,
Of Counsel for Complainants.
MILLER, PECKHAM & DIXON,
Defendants' Attorneys.

2019

U. S. CIRCUIT COURT,

FOR THE SOUTHERN DISTRICT OF NEW YORK.

[IN EQUITY.]

AMERICAN BELL TELEPHONE COMPANY ET AL.,
Complainants,

AGAINST

MOLECULAR TELEPHONE COMPANY ET AL.,
Defendants.

Testimony taken on the part of the defendants pursuant to Rule 67 of the U. S. Supreme Court, as amended, this 12th day of May, 1884, at No. 29 Wall street, in the City of New York, before me,

JOSEPH A. WELCH,
Special Examiner.

PRESENT:

MR. GEO. L. ROBERTS, Counsel for Complainants.

MR. WHEELER H. PECKHAM, MR. A. Q. KEASBEY, and MR. W. S. KNOX, Counsel for Defendants.

1. Defendants put in evidence an extract from the work entitled "'Der Elektromagnetische Telegraph,' by Dr. H. Schellen, 1867," as the same is printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pages 694, 695, 696, 697, and as there entitled, and with the accompanying cuts.

2. Defendants also put in evidence extract from publication entitled "'The Electric Telegraph,' by Robert Sabine, London, 1867, pages 136–138," as the same is printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pages 697, 698, 699, with the accompanying cuts, and as there entitled.

3. Defendants also put in evidence an extract from a work entitled "'Electricity and Magnetism,' by Jenkin, a book printed and

published in London and in the City of New York, in the year 1873," pages 334, 335, 336, to be marked "Defendants' Exhibit Extract from Electricity and Magnetism, by Jenkin. J. A. W., Sp. Examiner."

4. Defendants also put in evidence an extract from "Hessler's Technical Physics, Vienna, 1866, Vol. 1, p. 648," as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pages 599 and 600, and as there entitled.

5. Defendants put in evidence "Yearly Report of the Physical Society at Frankfurt-a-M., 1860–61, pp. 57–64 (published in 1862)," as the same is printed on pages 537, 538, 539, 540, 541, 542, 543, 544 of the printed record in the case, American Bell Telephone Company vs. Amos E, Dolbear *et al.*, with the accompanying plates, and also with three additional plates contained in the original publication and entitled respectively "Umkehrungen eines Dreiklanges, Tafel I," and "C dur. Tafel II," and "Tafel III."

6. Defendants also put in evidence extract from "A printed publication in the German language, entitled Zeitschrift des Deutsch Oesterreichischen Telegraphen-Vereins," Vol. 9, a book printed and published at Berlin, in 1862, as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al*, on pages 547, 548, 549, 550, 551, 552, 553, and as there entitled, with the accompanying plates.

7. Defendants also put in evidence extract from "A printed publication in the German language entitled 'Die Neueren Apparate der Akustik,' von De Prof. Fr. Jos. Pisco, printed and published in 1865," as the same is printed on pages 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, to be divided and entitled as in the printed record, by the above pages, in the case of the American Bell Telephone Company vs. Amos E. Dolbear *et al.*

MAY 13, 1884.

8. Defendants put in evidence extract from a work entitled "Electricity, by R. M. Ferguson," published in London and Edin-

burgh in 1867, at pp. 257, 258, as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 601, 602, 603, with the accompanying cut, and as there entitled.

9. Defendants put in evidence "The Telegrapher" published in the City of New York, in 1869, Vol. 5, No. 39, containing a reprint of Dr. Van der Weyde's Article, in the "Manufacturer and Builder" for May, 1869.

10. Defendants put in evidence "The Manufacturer and Builder," a journal published in the City of New York, for May, 1869, Vol. 1, No. 5, at page 129 to foot of article in first column of page 130.

11. Defendants put in evidence an article from a work entitled "The Wonders of Electricity, translated from the French of J. Baile. New York, Scribner, Armstrong & Co., 1872, pp. 140–143," as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 611, 612, 613, and as there entitled.

12. Defendants put in evidence extract from Dingler's Polytechnic Journal, Vol. 169, p. 399, as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 571, 572, and as there entitled.

13. Defendants put in evidence "Cosmos," Vol. XXIV., pages 349, 352, printed and published at Paris, March 22, 1864, as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 577, 578, 579, 580, and as there entitled.

14. Defendants put in evidence extract from "Koenig's Catalogus des Appareils d' Acoustique," Paris, 1865, page 5, as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 581, 582, and as there entitled.

15. Defendants put in evidence extract from Du Moncels' Expose des Applications de l' Electricite, vol. 2, p. 225, edition 1854, vol. 3, p. 110, edition 1856, as the same is printed in the printed

record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 532, 533, 534, and as there entitled.

16. Defendants put in evidence three extracts from "Didaskalia," a journal published in Frankfort-on-the-Main, Sept. 28, 1854, No. 232, and on May 11, 1862, No. 130, and on May 14, 1862, No. 133, the first of the same as it is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear, *et al.* pp. 531, 532, and as there entitled, and the second and the third of the same as they are printed on pp. 66, 67 and 68 of a printed publication entitled "Philipp Reiss, Inventor of the Telephone," by Silvanus P. Thompson, B. A. D. &c., Professor of experimental Physics in University College, Bristol, London, 1883.

Counsel for complainants objects to the introduction of the last two extracts from Thompson's book, as inadmissible and incompetent.

17. Defendants put in evidence extract from "Frankfurter conversationsblatt, Nov. 29th, 1861, and June 30th, 1863, as the same is printed in the printed record American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 535, 536, 537, and as there entitled.

18. Defendants put in evidence extract from "Fortschritte Der Physik, XVII., for 1861, pp. 171–3," a Journal published in Berlin, as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 544, 545, 546, and as there entitled.

19. Defendants put in evidence extract from "Lehrbuck der Physik and Meteorologic, Von Joh. Muller, Liebente Auflage, Zweiter Band, 1868, pp. 386–389, Galvanisches Tonen," as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 603, 604 and 605, with the accompanying cuts, and as there entitled.

20. Defendants put in evidence extract from "Bottger's Polytechnisches Notizblatt," Nos. 1 to 24 inclusive, published in 1863, as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 557, 558, 559, 660, and as there entitled.

21. Defendants put in evidence extract from "Deutsches Klinik, No. 48, Nov. 28, 1863, pp. 468, 469, as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, p. 535, and as there entitled.

22. Defendants put in evidence extracts from the "Deutsche Industrie Zeitung, 1863, Chemnitz," as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 553, 554, 555, 556, 557, and as there entitled.

23. Defendants put in evidence extract from "Die Gartenlaube," No. 51, December, 1853, as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 572, 573, 574, 575, 576, 577, with the accompanying cut, and as there entitled.

24. Defendants put in evidence extract from "Polytechnisches Centrablatt, 1863, pp. 857–9," as printed in printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, p. 560, and as there entitled.

25. Defendants put in evidence extract from "Journal of the Society of Telegraphic Engineers and of Electricians for March, 1883, No. 46," as printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 561, 562, 563, 564, with the accompanying cut, and as there entitled.

26. Defendants put in evidence "Tagesblatt der 39 Versammlung Deutsche Naturforscher," published in Giessen, in September, 1864, as the same is printed on page 94 of Prof. Sylvanus P. Thompson's book on Philipp Reiss, before referred to.

Objected to as inadmissible and incompetent.

27. Defendants put in evidence "Zollner's Buch der Erfundengen," published in Leipsic and Berlin in 1865 and in 1872.

[See Deposition Dr. Van der Weyde, Ints. 194, 195.]

28. Defendants put in evidence extract from "Handbuch der Angewandten Elecktricitatslehre Von Karl Kuhn, 1865, pp. 1017–1021," as the same is printed in the printed record, American Bell

20324

Telephone Company vs. Amos E. Dolbear *et al.*, pp. 593, 594, 595, 596, 597, 598, 599, with the accompanying plates, and as there entitled.

29. Defendants put in evidence extract from "Catalogue of J. Wilh. Albert, mechanician at Frankfort-on-the-Main, 1873," as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, p. 613, and as there entitled.

30. Defendants put in evidence "Zeitschrift Deutsch Oesterrichischen Telegraphen-Vereins," published at Berlin, Prussia, in the year 1862, Vol. 9, p. 125; containing a reprint of the "Reis-Legat Article."

31. Defendants put in evidence extract from "Aus der Natur," published in Leipsic, 1862, Vol. 21, pp. 470, 471 to p. 484.

32. Defendants put in evidence extracts from "Zeitschrift des Architectur und Indenieur Verein," 1866, Vol. 12, p. 147, marked "J. A. Welch, Special Examiner, May 13, 1884."

33. Defendants put in evidence extract from "The Dublin Medical Press," 1863, Vol. 50, No. 1293, p. 471, marked "J. A. Welch, Special Examiner, May 13, 1884."

34. Defendants put in evidence extract from "Cosmos," 1863, Vol. 23, p. 705, marked "J. A. Welch, Special Examiner, May 13, 1884."

35. Defendants put in evidence extract from "Scientific American Supplement," February 5, 1876, pages 92, 93, marked "J. A. Welch, Special Examiner, May 13th, 1884."

36. Defendants offer in evidence extract from "Scientific American," of March 4th, 1876, as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, pp. 614, 615, 616, 617, with the accompanying plate, and as there entitled.

MAY 14, 1884.

37. Defendants put in evidence extract from "Electric Telegraph," by Dr. Lardner, pp. 164–167, as the same is printed in the printed record, Bell Telephone Company vs. Peter A. Dowd, pp. 699, 700, 701, 702, with the accompanying cuts, and as there entitled.

38. Defendants put in evidence extract from "Annual Report of American Association for the Advancement of Science," for 1869, as the same is printed in the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, p. 610, and as there entitled.

39. Defendants put in evidence extract from "The Telegraphic Journal and Electrical Review," published in London in the year 1875, Vol. 3, at pp. 286, 287, 288.

40. Defendants put in evidence Letters Patent of the United States, granted to Thomas A. Edison and George Harrington, dated August 12, 1873, No. 141,777, as the same are printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pp. 571, 572, 573, with the accompanying plate, and as there entitled.

41. Defendants put in evidence Letters Patent of the United States, granted to Elisha Gray, July 27, 1875, No. 166,096, as the same are printed on pages 615, 616, 617, 618, 619, 620, in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, and as there entitled.

42. Defendants put in evidence Letters Patent of the United States, granted to Elisha Gray, dated July 27, 1875, No. 166,094, as the same are printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pp. 577, 578, 579, with the accompanying cut, and as there entitled.

43. Defendants put in evidence Letters Patent of the United States, granted to Elisha Gray, dated July 27, 1875, No. 166,095, as the same are printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pp. 579, 580, 581, 582, with the accompanying cut, and as there entitled.

2026

Also, as printed on pp. 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615 of the same record, and as there entitled.

44. Defendants put in evidence caveat filed by Elisha Gray in the United States Patent Office, February 14, 1876, as the same is printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pp. 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, with the accompanying plate, and as there entitled.

45. Defendants put in evidence Letters Patent of the United States granted to Elisha Gray, dated April 11, 1876, No. 175,971, as the same is printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pages 651, 2, 3, 4, with the accompanying plates, and as there entitled.

46. Defendants put in evidence Letters Patent granted to Elisha Gray, dated January 16, 1877, No. 186,340, as the same is printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pp. 667, 668, 669, 670, 671, and as there entitled.

47. Defendants put in evidence British Letters Patent granted to Cromwell Fleetwood Varley, dated April 8, 1870, No. 1044, as the same is printed in the appendix to the printed record, American Bell Telephone Company vs. Amos E. Dolbear *et al.*, between the printed patent No. 78,495, and the printed patent No. 239,742, with the four accompanying plates, and as there entitled.

48. Defendants put in evidence British Letters Patent granted to John Henry Johnson, July 29, 1874, No. 2646, as the same are printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pp. 565, 566, 567, 568, 569, 570, 571, with the accompanying plates, and as there entitled.

49. Defendants put in evidence British Letters Patent granted to Charles Wheatstone and William F. Cooke, dated January 21, 1840, No. 8345, as the same are printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pp. 501 to 546, inclusive, and as there entitled.

50. Defendants put in evidence Letters Patent of the United States granted to Elisha Gray, dated February 15, 1876, No. 173,460,

as the same is printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pp. 650, 651, with the accompanying plate, and as there entitled.

51. Defendants put in evidence Letters Patent of the United States granted to Elisha Gray, dated July 20, 1875, No. 165,728, as the same are printed in the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, pp. 573, 574, 575, 576, with the accompanying plate, and as there entitled.

52. Defendants put in evidence Letters Patent of the United States granted to Robert M. Lockwood and Samuel H. Bartlett, dated June 15, 1880, number 228,824, and marked "Defendants' Exhibit Lockwood & Bartlett's Patent for transmitter for telephones, J. A. Welch, Special Examiner, May 14, 1884."

53. Defendants put in evidence Letters Patent of the United States granted to Robert M. Lockwood and Samuel H. Bartlett, dated June 15, 1880, number 228,825, and marked "Defendants' Exhibit Lockwood and Bartlett Patent for Telephone Receiver, J. A. Welch, Special Examiner, May 14, 1884."

54. Defendants put in evidence the deposition of William M. Goodridge taken in case, Bell Telephone Company *et al* vs. Peter A. Dowd, as the same is printed in the printed record in said case, pp. 68 to 110 inclusive, and on pages 269 to 278 inclusive; also the deposition of Elisha Gray taken in said case, as the same is printed in the same record, on pages 111 to 156 inclusive, and on pages 279 to 285 inclusive; also the exhibits printed in said record on pages 573 to 691 inclusive, with the preceding plate, and the plate exhibits printed between pages 718 and 719 of said record, and as there entitled, and the exhibits printed in said record from pages 719 to 735 inclusive, and the plates printed between pages 735 and 736 of said records, and as there entitled, and the exhibits printed on pages 736 to 746 inclusive, and the plates printed between pages 746 and 747, and as there entitled, and the exhibits printed between pages 747 and 760 inclusive; also the plates printed on pages 762 to 771 inclusive, also on pages 773; also the first three exhibits on page 775, and as there entitled, except the reference to the record.

55. Defendants put in evidence the testimony for James W. Mc-

2858

Donough with the accompanying exhibits, taken in the speaking telephone interferences, to the end of page 67, marked "Defendants' Exhibit McDonough evidence, J. A. W., Special Examiner, May 14, 1884."

56. Defendants put in evidence copy of stipulation between the respective parties in this suit, and the same is marked "Exhibit Stipulation of parties, J. A. Welch, Special Examiner, May 14, 1884."

MAY 20, 1884.

57. Defendants put in evidence Letters Patent of the United States granted to Elisha Gray, dated February 15, 1876, number 173,613, and the same is marked "Defendants' Exhibit, Gray's Patent of February 15, 1876, J. A. W., Special Examiner, May 20, 1884."

58. Defendants put in evidence Letters Patent of the United States, granted to Alfred G. Holcomb, dated May 15, 1860, number 28,274, and marked "Defendants' Exhibit Patent of Alfred G. Holcomb, J. A. W., Special Examiner, May 20, 1884."

59. Defendants put in evidence Letters Patent of the United States granted to William Thompson, dated November 17, 1874, number 156,397, and marked "Defendants' Exhibit Patent of William Thompson, J. A. W., Special Examiner, May 20, 1884."

JUNE 7, 1884.

60. Defendants offer in evidence United States Patent Office copy of Specification forming part of Letters Patent No. 32,478, dated June 4, 1861.

It is stipulated between the counsel, Mr. Dickerson, for complainants, and Mr. Peckham, for defendants, that the preceding exhibit being specification of Letters Patent, No. 32,478, dated June 4, 1861, shall have the same force and effect in this cause as if the same had been specifically set up in the answer.

J. A. WELCH,
Special Examiner.
JUNE 18, 1884.

61. Defendants offer in evidence an article entitled "Improvement in Electro-Magnets," printed in the "Scientific American," New Series, Vol. III., No. 17, October 20, 1860, p. 264, and the same is marked "J. A. W., Sp. Exr., June 18, 1884."

J. A. W.,
Sp. Exr.

(No. 1.) Defendant's Exhibit Schellen Translation.

J. A. W., Examiner.

[Introduced, Record, page 4.]

TRANSLATION FROM WORK ENTITLED "DER ELECTROMAGNETISCHE TELEGRAPH," BY DR. H. SCHELLEN, 1867, PAGES 539-542.

"Figure 375 represents the action of the electro-magnet E upon the printing mechanism of the apparatus, and also the device for coupling together the two parts *b* and *b'* of the printing axis.

"The cores of the electro-magnet are not connected together at the back by a yoke, as in the case of an ordinary electro-magnet, but as shown in Fig. 376, they are attached to the N and S poles of a powerful steel magnet. The action of this magnet upon the cores is regulated by means of an armature of soft iron placed on the legs N and S which can be moved up or down. The nearer it is placed to the end of the poles the less will be the magnetic effect upon the cores of the electro-magnet.

"By this arrangement the cores are constantly magnetic, and attract the armature *n* (Fig. 375), as long as no current passes through the coils. A strong steel spring *r* operating on the arm F serves by its attractive power to withdraw the armature when, by the passage of a current through the coils, the magnetic power derived from the steel magnet is neutralized. In order to avoid too strong an attraction, the armature does not touch the surface of the poles, but is separated by a space equal to about the thickness of an ordinary sheet of paper.

"When a current whose polarity is opposite to the polarity of the steel magnet is passed through the coils E, E the magnetism is weakened or neutralized, and it no longer holds the armature against the retractile force of the spring *r*, which immediately draws the armature upward with considerable power. This movement is

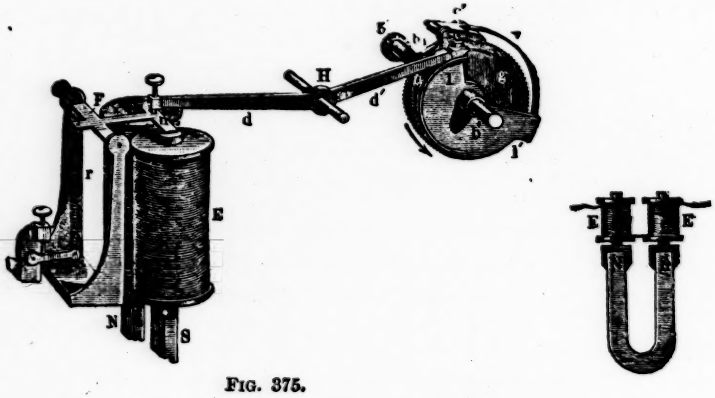


FIG. 375.

communicated to the lever $d\ d'$ which has its center of motion at the axis H. One end of the lever rests, with an adjusting screw, on the top of the armature; therefore, when under the action of the current, the armature is released and flies upward, one extremity d is raised with it, while the other goes downward, and it is by this movement that the coupling of the two portions of the printing axis $b_1\ b'$ (Figs. 369 and 370) is effected, and the motion of the wheel work transmitted from the pinion 5 to the front part of the printing axis b' and its four cams.

"The transmission of this motion is effected in the following manner: On the back part of the printing axis b_1, a wheel g (Fig. 375), with very fine and strong teeth, is fixed. On the front part of the axis b' is a circular sector $l\ l'$, on one side of which is a flyer c', to which is attached a detent c''. This detent has three teeth which gear into the teeth of wheel g. On the other side of the sector is a spring b which presses down the toothed detent, which with its flyer c' is allowed to rise and fall a little. When it is free as represented in Fig. 375, the spring v presses the detent c'', into the teeth of wheel g, and it revolves with the wheel in the direction indicated by the arrow, and thus the rotation of printing axis b_1 at once effects the revolution of the circuit $l\ l'$ and the axis b_1. When, however, $c'\ c''$ is raised, its teeth leave the wheel g; the latter continues to turn while the motion of the sector and the axis b' is arrested.

"The sector $l\ l'$ also carries an eccentric cam u, which raises the end d' of the lever, when by the action of the armature n it has fallen. This movement presses the armature against the poles of the magnet, where it remains attracted by the permanent magnetism of the

cores so long as no current passes through the coils. When in the position shown in the engraving, the sector *l l'* turns in the direction of the arrow, and after making half of a revolution the front part (in Fig. 375 the lowest part) of the cam *u* slides under the extreme end of lever *d'*. As the following end of the cam is more distant from the axis *b'* than the front end, the extreme end of lever *d'* is raised by the cam, the other end *d* consequently falls and the adjusting screw returns the armature to the poles of the electro-magnet.

"In the figure the front end of the cam *u* has not reached the end of the lever *d*, therefore this end is depressed, and the toothed detent is still engaged with the teeth of wheel *g*. When the axis *b'* is turned a little farther *d'* will have reached its highest position, and *d* will be resting against the armature of the magnet. The axis *b'*, sector *l l'*, and flyer *c'* continue to revolve; but when the revolution of the axis *b'* is nearly completed the flyer *c'*, to which *c''* is attached, reaches the inclined end of the arm *d'*, which is now firmly held, and moves upward, lifting *c''* out of the teeth of wheel *g* By this the printing axis *b'* is disconnected from *b*, and the revolving wheel work and its motion arrested, in which position of rest it remains until the arm *d'* again falls, owing to the release of the armature by a current passing through the coils, when the flyer *c'* is set free; *c''* again catches into the wheel *g*, and thus both *b'* and *b* are again coupled together. It will be seen that the printing axis *b'* makes a complete revolution at each action of the electro-magnet, and that the movement of armature *n* and the release and action of the printing mechanism is effected exclusively by mechanical power, and not by the power of an electric current. The current, during its very short duration, merely weakens or destroys the permenant magnetism of the cores of the magnet, at which the spring *r* raises the armature *n* and through the lever *d d'* regulates the motion of the printing mechanism."

(No. 2). Defendants' Exhibit, Extract from publication entitled "The Electric Telegraph," by Robert Sabine, London, 1867, pages 136-138.

J. A. W., Examiner.

[Introduced, Record, page 4.]

"84. *The Magneto-Induction Key.*—Instead of the Morse key, induction coil, and local battery, Siemens and Halske use also an instrument arranged in the form of a key, by which a coil of wire, wound on a soft iron armature, is oscillated between the poles of a permanent magnet, and develops alternate currents for working the polarized relay.

"The magneto-induction key is shown in Fig. 75 in perspective. S and N are two rows of permanent bar-magnets; the upper ones with their North ends, and the lower ones with their South ends in contact with a stout plate, *p*, of soft iron in the same way is in the transmitter of the magnetic electric pointer telegraph of the same inventors. Between the poles of this system, and oscillated in an angle of a few degrees by means of a handle, H, in the frame between two screw points, is a soft iron armature as long as the magnet system is wide, cut in deep longitudinal grooves on opposite sides, as is shown by the sectional sketch Fig. 76. In these grooves the coil C of fine insulated wire is wound. The play of the handle is limited by two adjusting screws in the frame A. When at

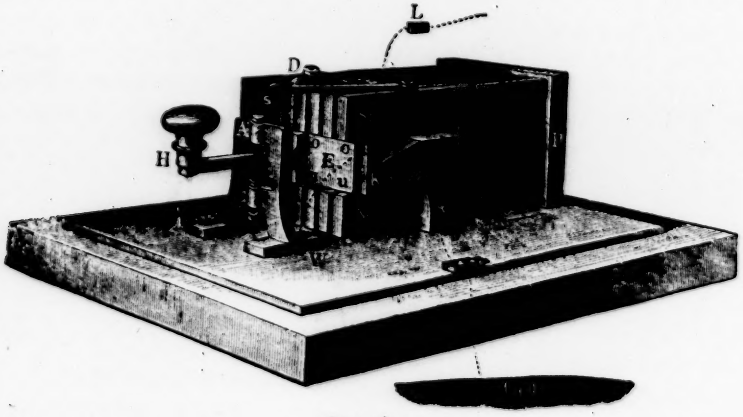
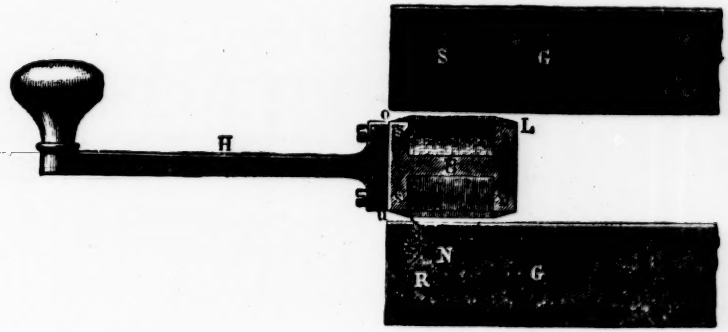


FIG. 75.

rest, the handle is held against the upper screw by a spiral spring S stretched between the handle and front of the triangular piece D on the top.



"One end of the coil of wire on the armature is attached to the screw *k* on the terminal K, from which one connection goes to line and another to the screw *w*, at the foot of the frame A. The other end of the coil is connected with the metal frame supporting the armature, and through the axis *f*, to the upright support Q, from which a leading wire goes to terminal *t* and earth.

"When the current arrives while the instrument is in circuit with the line, it goes from L over R, W, upper adjusting screw in A, through handle H, axis *f*, Q, *t*, earth, without traversing the coil. This is the purpose of the connection between R and W.

"When the handle is pressed down, the polarity of the armature is reversed, and a positive magneto-electric current induced in the coil, which circulates also in the line wire, and deflects the tongue of the polarized relay at the receiving station, from the insulated point, and closes the local circuit so long as the key is held down, and no negative current induced by letting the key go back to its position of rest."

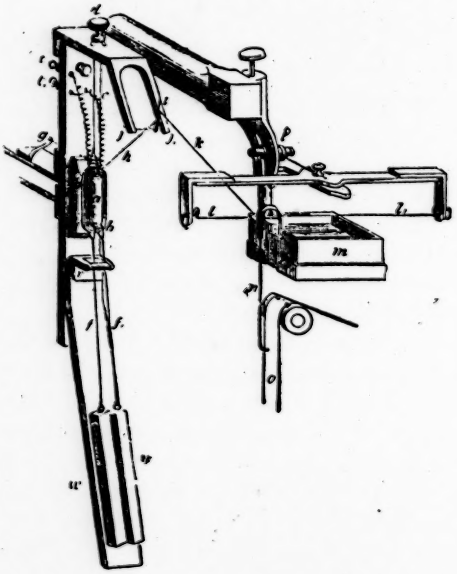
[No. 3.] Defendants' Exhibit, Extract from "Electricity and Magnetism," By Jenkin.

J. A. WELCH, Special Examiner, May 12, 1884.

[Introduced, Record, page 4.]

§ 5. Sir William Thomson's syphon recorder actually draws on paper the curves which we have learnt to construct theoretically. Ink is spurted from a fine glass tube on to paper drawn past it with

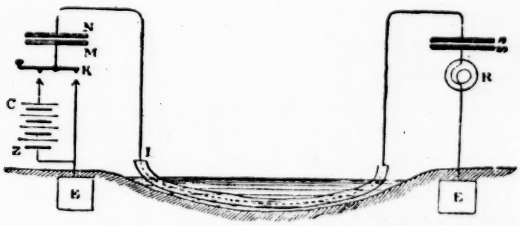
FIG 162



a uniform motion; the glass point of this tube moves to the right or left through distances proportional at each instant to the strength of the current, and thus the signals are drawn on the paper in the form of curves representing the strength of the current at each instant of time.

The glass tube *n* (Fig. 163) is pulled backwards and forwards by being connected through the threads *k h* and lever *i* with a very light movable coil *b b* placed between the two poles of a very powerful electro-magnet, not shown. A soft iron fixed core *a* is placed

in the center of the coil. The coil oscillates about a vertical axis, being directed by a bifilar arrangement $f f_1$. The received current passes through this coil from the terminals $t\ t_1$; the vertical arms of the coil are impelled across the magnetic field in one direction or the other according to the sign and strength of the received current. The magnetic field in this arrangement is very intense and very uniform, which gives great sensibility to the apparatus. The glass syphon n is strung on the wire $l\ l_1$, the shorter end dips in the ink-trough m, and the longer end is opposite the paper o; the syphon can be withdrawn from the ink by the slide p; the spring g keeps the threads $k\ h$ taut; the directing force of the bifilar arrangement is adjusted by varying the position of the bracket r; the two weights $w\ w_1$ hang from the coil by the two directing threads. If the coil is shunted so that there is a comparatively short circuit through which the current induced by its motion can flow, the electro-magnetic induction of the magnet on the coil tends to check rapid oscillations not due to the signals.



A certain portion of the received current is lost through the shunt, which is, however, rarely required, for the capacity of the cables connected with the coil is such that a very sensible induction takes place even without the shunt.

The ink is electrified by an induction machine similar in principle to that described in Chapter XIX, § 1, and is thus made to fly to the oppositely electrified strip of paper in a succession of fine drops.

2057

(No. 4.) Defendants' Exhibit, Hassler's Description of Reis.

Extract from *Hassler's Technical Physics, Vienna,* 1866, *Vol. I, p.* 648.

J. A. W., Sp. Ex'r.

[Introduced, Record, p. 5.]

The subject of phonotelegraphy will end this chapter. This rests upon a phenomenon first observed by Page, afterwards confirmed by Mariana, and more exactly studied and experimented upon by Wertheim; that is, that iron, under the influence of alternate magnetizing and demagnetizing by means of a galvanic helix, is set in longitudinal vibration and gives forth sound; and Reis showed beyond doubt the possibility of phonotelegraphy by means of an apparatus called by him telephone (Fig. 429), consisting of two parts—the actual telephone (I), and the reproduction apparatus (II), used at the second station at a distance. Both parts are connected with one another and with a battery *s*, as in ordinary telegraphs. The battery *s* must be strong enough to work the armature *a* of the electro-magnets *e e* (three or four six-inch Bunsen's elements are sufficient for a distance of several hundred feet). The current passes from *s* to the binding screw 2, thence through the strip of copper *n* into the disk of platinum *o*, resting on the middle of a thin circular membrane (hog's gut) stretched across the upper end of the wooden box *k;* afterwards it goes through the foot (platinum point) of the metallic angle *a b c* (this point standing on the disk *o*), into a vertical screw, provided with a small cavity at its upper end containing a drop of mercury, into which there dips from *a a*, a platinum point suspended above, while the angle *a b c* rests at *c*, on a small metallic pillar, so as to be very easily made to vibrate about *a* and *c*. From this pillar (at *c*) the current goes through the key *t* and into the binding screw *i* connected with the wire leading to the pillar, thence through a wire stretched from this screw into the binding screw 3 on the apparatus 4, then through the key *t* of this apparatus into the bobbin *g* (magnetizing coil), inclosing the iron or steel wire *d d*, of the thickness of a knitting needle into the binding screw 4, and finally thence by wire back to the second-pole of the battery *s*. If, now, we produce sufficiently strong tones by means

of organ pipes in front of the opening of the tube T (or sing them through the tube T in the hollow box *k*), the waves of the sound set the membrane *m* into regular vibrations. Every condensation occurring beneath *m* at once raises the disk of platinum *o*, together with the platinum point *b* (the foot of the angle *a b c*) when the rarefaction occurs and *m* moves downward again, the angle *a b c* cannot immediately follow the disc *o*, and the current is interrupted, and a similar interruption occurs with every vibration of *m*, and in this way are produced just as many vibrations in the wire *d*, *d* of the coil *g*, at station II as the membrane makes; these vibrations are perceived there as tones and combination of tones (accords). These tones are much strengthened by covering the coils with a box of resonant wood *d* for a sounding board, so placed as to fit the sounding board *b* below. The keys X and X make it possible to communicate short messages as necessity arises, between station I and II (*E. G.*, to signify from II to I that they are ready to receive communications at II). For by pressing down the keys the electromagnet *e* is included in the circuit, the armature *a* drawn up and made to strike upon *e*.

The telephone is yet in its infancy, it is true, but even now, by employing powerful currents it transmits at a distance not only solitary tones, but even tunes consisting of slow consecutive tones, quite perceptibly and distinctly.

2039

(No. 5). Defendants' Exhibit, Reis Lecture.

JAHRES-BERICHT DES PHYSIKALISCHEN VEREINS ZU FRANKFURT AM MAIN; FUR DAS RECHNUNGS JAHR, 1860–61.

Yearly Report of the Physical Society at Frankfort-a-M., 1860–61; pp. 57–64 (published in 1862).

J. A. W., Sp. Ex'r.

[Introduced, Record, page 5.]

"*On Telephony by Means of the Galvanic Current, by Philipp Reiss.*"

The extraordinary results in the field of telegraphy have probably often raised the question, if it might not be possible to transmit musical tones themselves (Tonsprache) to a distance? Experiments made in this direction could not, however, produce any result at all satisfactory, because the vibrations of conducting media soon loose their intensity to such an extent that they are no longer appreciable by our senses.

A reproduction of tones (Tonen) at certain distances by means of a galvanic current has probably been thought of, but the practical solution of this problem has certainly seemed the most doubtful to the very persons who, from their knowledge and appliances, were in the best condition to attack it. To a person having only a superficial knowledge of physics the problem presents far less difficulties, simple because the most of them are unperceived. About nine years ago I also (having an extraordinary enthusiasm for what was new and an insufficient knowledge of physics) had the boldness to attempt the solution, but was soon forced to desist because the very first experiment convinced me of the impossibility of its solution.

Later, after further study and experience, I came to see that my first experiment had been a very rough and by no means conclusive one; I did not, however, follow up the subject seriously, because I did not feel myself equal to the difficulties in the way.

Youthful impressions, however, are strong, and therefore not easily effaced. I could never get rid of the thought of that first experiment and its occasion, notwithstanding all that reason says to the contrary, and thus, half unwillingly, this project of my youth was reviewed in hours of leisure; the difficulties and the means for

overcoming them were weighed; but for the present, at least, no experiment was made.

How indeed could a single instrument reproduce the combined effect of all the organs occupied in human speech? This was always the cardinal question; finally I got the notion of putting the question in another way—

How is *our ear* affected by the totality of vibrations produced by the organs of speech, all simultaneously active? Or more generally—

How are we affected by the vibrations of several simultaneously sounding bodies?

To answer this question, we must, in the first place, understand what must happen in order that we may perceive a single tone.

Without our ear, any tone is nothing else than a recurrent condensation and rarefaction of some body repeated at least seven or eight times in a second. If this occurs in the same medium in which we are, the membrane of the ear is at each condensation forced towards the middle ear, to be moved at the subsequent rarefaction in the opposite direction. These vibrations produce a synchronous raising and falling of the hammer upon the anvil (according to other authorities, an approach or receding of the ear bone particles), and a similar number of tremors in the fluid of the cochlea, in which the filaments of the auditory nerve are distributed. The greater the condensation of the conducting medium at any given moment, the greater is the amplitude of vibration of the membrane and hammer, and consequently the more powerful the blow upon the anvil and the vibration of the nerves by means of the fluid.

The office of our organs of hearing is, therefore, to transmit with certainty up to the auditory nerve every condensation and rarefaction occurring in the surrounding medium. But the office of the auditory nerve is to bring to our consciousness the vibrations of matter which have occurred in a given time, both as regards number and amplitude. Here, for the first time, certain combinations receive a name; here, certain vibrations are *tones* or *noises* (*Töne oder Misstöne*).

What our auditory nerve perceives is, then, simply the effect of a force coming within the range of consciousness, and this force can be represented both as to duration and magnitude graphically by a curve.

Let *a b* represent any given time, and the curve above the line condensation (+), the curve below the line rarefaction (—), then

2041

any ordinate raised from the end of any abcissa will represent the degree of condensation, at the time represented by its base, in consequence of which the drum of the ear vibrates.

Our ear can under no circumstances appreciate more than can be represented by these curves, and this, indeed, is entirely sufficient to give us a clear perception of any tone (*Ton*) or any combination of tones.

If several tones (*Tonen*) are produced at the same time, the conducting medium is subjected to the influence of several simultaneous forces, and the two following laws will hold good. If the forces act in the same direction, the amplitude is proportional to the sum of the forces; if the forces act in opposite directions, the amplitudes are proportional to the difference of the opposing forces.

If, for example, in the case of three tones, we draw the curve of condensation of each separately, then by a summation of the ordinates of corresponding abscissas, we can determine new ordinates and develop a new curve, which might be called the combination curve. This represents exactly what our ear perceives of the three simultaneous tones. The fact that the musician can distinguish the three tones need not surprise us any more than the fact that any one acquainted with the theory of colors can in green discover blue and yellow; but the combination curves in Plate I. show that this difficulty is a slight one, for in these curves all the relations of the components successively recur. In the case of chords, of more than three notes the relations are not so readily seen from the drawing, Plate II., for example. In the case of such chords, however, the skilled musician also finds difficulty in recognizing the separate notes.

Plate III. illustrates discord (*Dissonanz*). Why discords impress us unpleasantly I will leave my readers to judge at this time, though I may, perhaps, return to the subject subsequently in another paper.

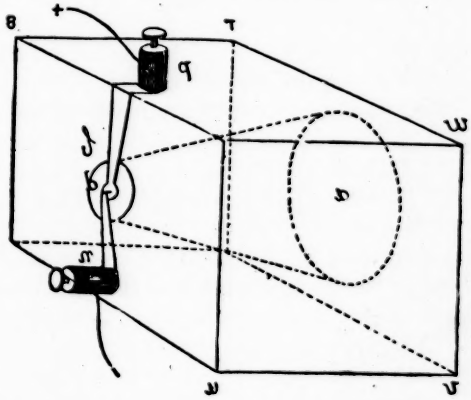
From the preceding it follows :

First. Every tone (*Ton*) and every combination of tones, on striking our ear, causes vibrations of the drum of the ear, the succession of which may be represented by a curve.

Second. The succession of these vibrations alone gives us a conception (*Sensation*) of the tone, and every alteration changes the conception (*Sensation*).

As soon then as it is possible to produce, anywhere and in any manner, vibrations whose curves shall be the same as those of any given tone or combination of tones, we shall receive the same impression as that tone or combination of tones would have produced on us.

With the above principles as a foundation, I have succeeded in constructing an apparatus with which I am enabled to reproduce the tones of various instruments, and even to a certain extent the human voice. It is very simple and by means of the figure will be easily understood from the following explanation :



In the cubical block of wood *r s t u v w x* there is a conical perforation *a*, closed at one end by a membrane *b* (pig's intestine), upon the middle of which there is cemented a conducting strip of platinum ; this is connected with the binding screw (*Auf deren Mitte ein stromleitendes Streichen Platin festgelittet ist. Dieses steht mit der Kleume p in Verbindung.*) From the binding screw *n*, another thin strip of metal (*ein dunnes Metallstreischen*) extends until over the middle of the membrane, and ends here in a platinum wire placed at right angles to its length and surface.

From the binding screw *p* a conducting wire runs through the battery to the distant station, being connected with a coil of silk-covered copper wire, and this again is connected with a conductor leading back to the binding screw *n*.

The coil at the distant station is about six inches long, is composed of six layers of fine wire, and, as a core in its centre, has a knitting needle which projects about two inches at both ends. By means of the projecting ends the coil rests upon two bridges of a resonant case. (All this part can of course be replaced by any other apparatus by means of which the well-known "galvanic tones" can be produced.)

If now tones or combinations of tones are produced in the neighborhood of the block, so that sufficiently powerful waves enter the opening *a*, then these sounds cause the membrane *d* to vibrate. At the first condensation the hammer-like wire *d* is pushed back; at the rarefaction it cannot follow the retreating membrane, and the current traversing the strip remains broken (Strom bleibt so lange unterbrochen bis, etc.), until the membrane forced by a new condensation again presses the strip (proceeding from *p*) against *d*. In this way each sound wave causes a breaking and closing (ein Oeffnen und ein Schliessen) of the current (Stromes).

At each closing (Schliessen) of the circuit (kette) the atoms of the iron wire inside the distant spiral are moved away from each other (Pouillet Muller, page 304, Vol. II., 5th edition); on breaking the circuit (beim unterbrechen des Stromes) these atoms seek to regain their position of equilibrium. When this happens, in consequence of the reciprocal actions of elasticity and inertia, a number of vibrations are produced, and they give the longitudinal sound of the rod (see as above). This is the case if the making and breaking of the current (Unterbrechungen und Schliessungen des Stromes) occur with comparative slowness. If they occur more rapidly then the oscillations of the iron core, due to its elasticity, the atoms cannot complete their course. The paths described become shorter in proportion as the interruptions are more frequent, but then are just as numerous as these.

The iron wire no longer gives its longitudinal (normal) tone, but a tone whose pitch corresponds to the number of interruptions (Unterbrechungen) (in a given time): This is the same as saying that *the rod reproduces the tone* (Ton) *impressed upon the interrupter* (dem Unterbrechunges apparat). The intensity also of this tone is proportional to that of the original one, for in proportion as this is

2041

more intense the motions of the membrane are greater; the motions of the hammer, also, and finally the time during which the circuit remains opened is greater, and, consequently, up to a certain limit the motions of the atoms in the reproducing wire are greater, we perceiving them as greater vibrations in just the same way as we would have perceived the original sound wave.

As the length of the conducting wire can undoubtedly be made as great as in direct telegraphy, I have called my instrument "telephone."

Now, in reference to the capabilities of the telephone, it may be stated that I was enabled to render audible to the members of a large, assembly (The Physical Society at Frankfort-a-M.) melodies which were sung not very loud into the apparatus in another house three hundred feet away with closed doors.

Other experiments showed that the sounding wire was capable of reproducing complete chords of three tones of the piano, upon which the telephone was placed, and that it reproduces equally well the tones of other instruments, accordeon, clarinet, horn, organ pipes, &c., provided that the tones are within the compass F—f.

Of course, in all experiments, sufficient precautions were taken to insure that there was no direct conduction of sound. This is very easily done by making a momentary short circuit immediately in front of the coil, by which means its action is temporarily interrupted.

Hitherto it has not been possible to reproduce the tones of human speech (Tonsprache des Menschen) with a distinctness sufficient for every one. The consonants are for the most part reproduced pretty distinctly, but the vowels, as yet, not in an equal degree. The cause of this I will attempt to explain.

According to the experiments of Willis, Helmholtz and others, vowel tones can be produced artificially if the vibrations of one body are from time to time augmented by those of another somewhat as follows:

An elastic spring is set in vibration by the blow of a tooth on a toothed wheel; the first vibration is the greatest, and each subsequent one is smaller than the preceding.

2041

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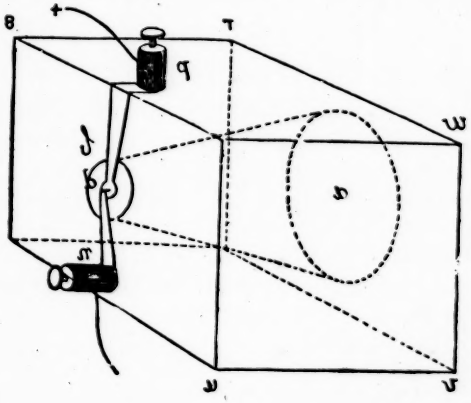

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2041

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According to the experiments of Willis, Helmholtz and others, vowel tones can be produced artificially if the vibrations of one body are from time to time augmented by those of another somewhat as follows:

An elastic spring is set in vibration by the blow of a tooth on a toothed wheel; the first vibration is the greatest, and each subsequent one is smaller than the preceding.

2045

If, after a few vibrations of this kind (the spring not coming to rest in the meantime), the tooth-wheel imparts a new stroke, the following vibration will be again a maxium, and so on.

The pitch of the tone produced in this way depends upon the number of vibrations in a given time, but the character of the tone upon the number of swellings (Anschwellungen) in the same time. Two vowels having the same pitch would differ in about the way represented by the curve (Figs. 1, 2), while the same tone without any vowel character would be represented by the curve (Fig. 3).

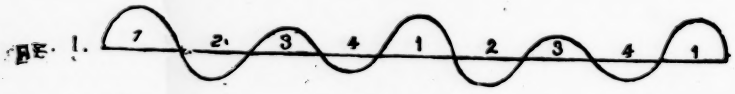


Fig. 1.

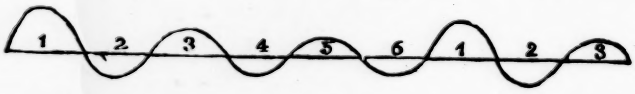


Fig. 2.

Fig. 3.

Our organs of speech probably produce the vowels in the same manner, through the combined action of the upper and lower vocal chords, or of these latter and the cavity of the mouth.

My apparatus reproduces the number of vibrations, but with an intensity much less than that of the original ones, though, as I have reason to believe, to a certain degree proportional among themselves. But in the case of these generally small vibrations the difference between large and small vibrations is more difficult to perceive than in the case of the original waves, and the vowels, therefore, more or less indistinct.

Whether or not my views as to the curves corresponding to sound combinations are correct could, perhaps, be decided by means of the new phonautograph of Duhamel ("Bierordt Physiology," page 254).

It may be that for the practical application of the telephone much remains to be done. For physics it has already sufficient interest, from the fact that it opens a new field for research. *Friedrichsdorf, near Frankfort-a-M., December*, 1861.

2049

(No. 6.) Defendants' Exhibit, "Reis-Legat Article."

Extract from "*Journal of the German-Austrian Telegraph Association, V.* 9, p, 1, 1862.

J. A. W., Sp. Ex'r.

[Introduced, Record, page 5.]

Concerning the reproduction of sounds by means of Galvanic Electricity; by V. Legat, Royal Prussian Telegraph Inspector at Cassel, accompanied by Copper Plates VIII. and IX.

It might not be uninteresting to make known, in wider circles, the following ideas lately communicated by Mr. Philip Reis to the Society of Physics and to the meetings of the Free German Institute, at Frankfort-on-the-Main, concerning the reproduction of tones (Tonen) by means of galvanic electricity, and, also, what has been hitherto accomplished towards the realization of this project, in order that the accumulated experiments may serve as a foundation to build upon, and that the capacity of the electric current, which, by human ingenuity, has already been made serviceable for correspondence, may be developed in this direction also.

In this essay we shall not deal with the electric current as to its capacity for operating telegraphic apparatus of whatever construction for the reproduction of *visible* signs, but of the application of this current to the production of *audible* signals—of *tones* (Tonen).

The air waves, which by acting upon the ear excite in us the sensation of sound by primarily setting the tympanum of the ear into vibratory motion, are, as is well known, transmitted to the interior parts of the ear, and to the auditory nerves there located, by means of a lever apparatus of wonderful delicacy, the auditory bones (hammer, anvil, stirrup), and the attempt to reproduce tones therefor depends upon this to actuate an artificial imitation of this lever apparatus by means of the vibrations of a membrane corresponding to the membrane of the ear-drum, and thereby to open and close (zum Oeffnen u. Schliessen) a galvanic circuit connected with a distant station by a metallic conductor.

Before describing the apparatus to be used it would be proper to enquire how our ear apprehends the vibrations of any one particular tone, and the combined vibrations of all simultaneous tones acting upon it, because thereby we may determine the operations

which are to be performed by the transmitting and receiving apparatus in the solution of the problem.

Examining first the processes which take place in order that the human ear may apprehend any single tone, we find that each tone is the result of alternate rarefactions and condensations repeated within a fixed time. If this operation occurs in the same medium in which the ear is placed, then at each condensation the membrane is forced toward the cavity of the drum and toward the opposite side at each rarefaction.

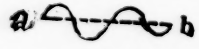
These vibrations cause corresponding movements in the auditory bones, and are thereby transmitted to the auditory nerves.

The greater the degree of condensation of the sound conductng-medium is at a given time, the greater will be the amplitude of vibration of the membrane and auditory bones, and the greater the consequent result; and in the opposite case, so much the weaker. Hence, it is evidently the function of the auditory apparatus to impart with faithfulness to the auditory nerves every condensation and rarefaction which occurs in the surrounding medium. On the other hand, the function of transmitting to our consciousness, both the number and amplitude of the resulting vibrations occurring within a given time devolves upon the auditory nerves.

It is here, in our consciousness, that a certein complex phenomenon receives a specific name. It is here, in our consciousness, that the transmitted vibrations become tones (Tonen).

Accordingly, that which is apprehended by the auditory nerves, is the effect of a force, reaching to our consciousness, and which can be made more easy of comprehension, as to its duration and strength, by graphical delineation.

For example, let the length of the line a – b represent a definite period of time, the curves above this line the condensations (+),



and the curves below this line the rarefactions (—), then every ordinate erected at the end of any abscissa will indicate at the moment of time indicated by this abscissa the degree of condensation in consequence of which the membrane of the drum vibrates.

The ear is not capable of perceiving more than can be represented in this way, or more than can be represented by similar curves; this is, however, sufficient to convey to our consciousness any single

tone (Ton) or any required combinations of tones. For, if several tones are generated simultaneously, then the tone-imparting medium is influenced by several forces, acting at the same time, and subject to mechanical laws.

If all the forces act in the same direction, then the amount of motion is in proportion to the sum of all the forces; if, on the other hand, the forces act in opposing directions, then the amount of motion is in proportion to the difference between the opposing forces.

From these principles, it follows that the curves representing the condensations of a number of simultaneously generated tones may be combined in a single curve of condensation, which will indicate with precision what our ear apprehends through the reception of these simultaneously acting tones.

The objection generally made to this proposition, that a musician, or any person, is able to distinguish the simple tones out of which these composite curves are formed or arise, should not be allowed to militate against it; as it is also possible for some who are familiar with the study of colors to distinguish in green, for example, the mixture of yellow and blue, in their varied shades; and the one phenomenon, as well as the other, is referable to the fact that each observer is very familiar with the factors of that product which has been conveyed to his consciousness.

By the explanations heretofore given, it is easy to construct the curves representing the condensations of various tones, chords, etc., and a few examples are given by way of illustration:

Fig. 1, Plate VIII, represents a composite curve, formed of three tones, in which all the proportions of the components recur successively.

Fig. 2 represents a similar curve, formed of more than three tones; in this case, however, it is no longer possible to represent the proportions so clearly in the drawing, yet an experienced musician will be able to discern them even here, although in practice it might be difficult for him to recognize the separate tones in such a chord.

The advantage of representing the operation of tones upon the human ear after this manner, is that it gives the clearest view possible of the course of the process; the representation here given also shows why a discord (dissonanz), Fig. 3, must affect the ear disagreeably.

This apparent digression from the subject under consideration was necessary to demonstrate that as soon as we are able, in any place and in any manner, to reproduce vibrations of such curves and intensities as are equivalent to the curves and intensities of the vibrations of any particular tone, or of any particular combination of tones, we shall have the same impressions as were produced upon us by this original tone, or these original combinations of tones.

The apparatus described hereafter offers the possibility of producing these vibrations in every manner desired; and by the use of galvanic electricity it is possible to evoke, at any distance, vibrations like (gleiche) those which have been so produced and in this way to reproduce in any place the tones which have been generated at another place.

In Plate IX, Fig. 4, A is the tone transmitter (Tonangeber), and B the tone receiver (Tonempfanger), and these two instruments are set up at different stations. I must observe at the outset that the arrangement of the instruments for sending backwards and forwards is omitted for greater clearness; and, likewise, as the whole thing is not presented as a completed fact, but only to call to the notice of a wider circle what has been already ascertained, the possibility of the working of the apparatus at a distance greater than the limited direct working allows at present is left out of consideration, since these points are easily accomplished by mechanical arrangements, and since the most important facts of the phenomena treated are not influenced thereby.

Let us now turn to the tone transmitter, Fig. 4 A. This on the one hand is connected by the metallic conductor with the tone reciver, Fig. 4 B, at a neighboring station; on the other hand it is connected by means of the electric battery C with the earth, or with the metallic return conductor. The tone transmitter, Fig. 4 A, consists of a conical tube *a b*, about 15 centimetres in length, having a front opening of about 10 centimetres, and a rear opening of about 4 centimetres.

It appears by practical experiments that neither the material of this tube, nor any increase in its length, influenced the accuracy of the action of the apparatus. An enlargement of the diameter of the tube impairs the working of the apparatus, and it is desirable that the inner surface of the tube be as smooth as possible. The smaller or rear end of the tube is closed by a collodion membrane *o*, and upon the center of the circular surface of this membrane rests one

end *c* of the lever *c d*, the supporting point *e* of which is sustained by a bracket, and is kept in electrical connection with the metallic conductor. The proper lengths of the respective arms *c e* and *e d* of this lever are regulated by the laws of the lever. It is advisable, to make the arm *c e* longer than the arm *e d*, in order that the least motion at *c* may operate with greatest effect at *d*. It is also desirable that the lever itself be made as light as possible, that it may follow the movements of the membrane. Any inaccuracy in the operation of the lever *c d* in this respect will produce false tones at the receiving station. When in a state of rest the contact at *d g* is closed, and a delicate spring *n* maintains the lever in this position.

The second part of the apparatus, the standard *f*, consists of a metallic support, connected with one pole of the battery C, the other pole of which is connected to the earth, or to a metallic return wire leading to the other station.

Upon the standard *f* is arranged a spring *g*, with a contact point corresponding to the contact point *d* of the lever *c d*; the position of *g* is regulated by the screw *h*.

In order not to impair the operation of the apparatus by the action of the air waves against the rear side of the membrane, it is desirable to place a disc of about 50 centimetres in diamater at right angles to the longitudinal axis of the tube *a b*; this disk may be attached to the tube by a fastening surrounding its outer circumference.

The tone receiver, Fig. 4 B, consists of an electro-magnet *m m*, which rests upon a sounding board *n w*. Its coil is connected respectively with the metallic conductor and the earth or the metallic return conductor.

Facing the electro-magnet *m m* is an armature, to which is attached a very long but light and broad lever *i*.

The lever *i* with the armature is suspended from the standard *k* in the manner of a pendulum, its motion being regulated by means of the screw *l* and the spring *q*.

In order to increase the capacity of the apparatus, the tone receiver may be placed at one of the focal points of an elliptical chamber of suitable size, and the listener may place his ear at the other focus of this chamber.

The operation of the apparatus described is as follows:

When at rest the galvanic circuit (kette) is closed, when the air, which is in the tube *a b* of the apparatus, Fig. 4 A, is alternately

2054

condensed and rarified by speaking into it (or by singing or introducing the tones of an instrument), a movement of a membrane closing the smaller opening of the tube is produced, corresponding to such condensation or rarefaction. The lever *c d* follows the movements of the membrane, and opens and closes (offnet und schliesst) the galvanic circuit (kette) at *d g*, so that at each condensation of the air in the tube the circuit is opened, and at each rarefaction the circuit is closed (ein oeffnen und ein Schliessen erfolgt).

In consequence of this operation, the electro-magnet of the apparatus, Fig. 4 B, in accordance with the condensations and rarefactions of the column of air in the tube *a b*, Fig. 4 B, is correspondingly demagnetized and magnetized (demagnetisirt und magnetisirt), and the armature of the magnet is set into vibrations like those of the membrane in the transmitting apparatus. But the beam (Balken) *i* attached to the armature communicates these corresponding vibrations of the armature to the air surrounding the apparatus Fig. 4 B, which finally transmits the vibrations so produced to the ear of the listener.

We have not here to consider the question of the transmission (Fortpflanzŭng) of tones by means of the galvanic current, but only of the conveyance (Uebertragŭng) of generated sounds to another place, and in this way that at the latter place a similar cause is produced and a similar effect obtained. It must not be ignored, however, that while the apparatus described reproduces the exact number of the original vibrations, but not of the same strength (die gleiche stärke der reproducirten schningŭngen noch nicht errecht nurde), and that the achievement of this result is reserved for an improvement of the apparatus.

In consequence of the imperfection of the apparatus at this time, the minor differences of the original vibrations are distinguishable with more difficulty—that is, the vowel sounds appear more or less indistinct—inasmuch as each tone depends not merely upon the number of the vibrations of the medium, but also upon its condensation and rarefaction.

This also explains why chords and melodies were transmitted with marvellous accuracy in the practical experiments hitherto made, while single words in reading, speaking, etc., were less distinctly recognizable, although even in these the inflections of the voice, as interrogation, exclamation, surprise, calling, etc., were clearly reproduced.

There is no doubt that the subject we have been considering, before it becomes practically valuable for use, will require considerable improvement. It will especially be necessary to perfect the mechanism of the apparatus to be employed. But I am convinced, by repeated practical experiments, that it is of the greatest theoretic interest to pursue these investigations, and also that a development of practical value will not elude our intelligent century.

2056

(No. 7.) Defendants' Exhibit, Pisko's Description of Reis.

J. A. W., Sp. Ex'r.

[Introduced in Record. page 5.]

PISKO.—*Die neueren Apparate der Akustik. Vienna, 1865, pp. 94, et seq.*

(Page 94). *a* 51. *Principles of the Telephone of Reis.* The "Telephone" of Reis (Fig. 60) is related to the Membrane-Phonautograph. The round end *s* of a light strip of platinum *n s* is fastened upon the membrane *m m* with wax in such a way that the strip of platium can make all of the vibrations of the membrane with it. Very near to this end *s* of the strip of platinum *n s* is a platina point fixed so that it is touched by the strip of platinum as this vibrates with the membrane. If we suppose the outer end *n* of the platina strip and the platina point to be connected with the poles of a battery, then a current is established or broken by the vibration (page 95) of the membrane, according to its phases. A magnetic piece of clock-work or an electro-magnetic telegraph introduced into this circuit, would transmit to a distance indications that some one was speaking, but they would, self-evidently, not be able to make known what was spoken.

b. It is well known that an iron wire, surrounded by strong galvanic currents frequently broken, is made to sound forth tones which may be longitudinal or transverse, or both at the same time. Reis introduced such a iron wire lying in a multiplying coil at the second station C. This produced tones, if the membrane was caused to vibrate by singing or talking into (S, Fig. 60) the hollow, cubical part A. In my experiments with the telephone the rod never changed its pitch even with the most different tones and sounds, and always produced only the rhythm of the words sung or spoken at S into the part A. The aria of the song sung into the instrument could generally be recognized from the rhythm. The experiments, with special reference to this, are recited in S 53. But this much is evident already, that time must yet elapse before the simultaneous concerts and singing productions so ardently hoped for by the newspapers. The apparatus of Reis is indeed a "Telephone," but not a "Phonic telegraph." The only means of transmitting song and speech, and this only for moderate distances, is the old, well-known speaking tube. But the experiment of Reis can always be

classed with the most beautiful and interesting of school experiments; and as the Reis means for producing it are simple, the apparatus of Reis will surely soon find its way even into moderately endowed institutions, that the sounding of the wire in the telephone is not due to acoustic transmission can be shown by cutting the coil out of the circuit; the sounding ceases at once.

1. Reis's Phon-autograph was originally made of a wooden cube with a conical cavity. The smaller opening was covered with the membrane. A knitting needle was used as the sounding wire, which projected about two inches out of each side of the multiplying coil, and rested upon two bridges of a resonance box. The surrounding (page 96) coil consisted of six layers of fine wire. Fig. 60 shows the telephone as it is at present manufactured, according to the inventor's directions, by artisan Albert, in Frankfort, and artisan Uanck (Hauck), in Vienna.

2. Even though the telephone cannot be used to reproduce concerts, this can be accomplished for moderate distances by the resonance of solid bodies, in narrow limits to be sure. Pepper, director of the Polytechnic Institute, formed at London amusing sciences, gave such a concert (185) with Wheatstone's method. Four of Erard's harps stood upon the stage; each had on its resonance board a short staff of pine two cm. thick.

By turning the harps on their axes, this staff was made to touch an exactly similar one, which went into a deep cellar, and there was in contact respectively with the sounding board of the piano, of a violincello, of a violin, and the mouthpiece of a clarinet.

As long as the resonance staffs touched, the concert was heard distinctly; but as soon as one or all the harps came out of contact with the sound-conducting staff the music ceased. The character of the instruments played was, as a whole, preserved, only the violincello tones being somewhat raspy.

52. *Particulars Regarding the Telephone.*

(a) It consists substantially of:
1. The transmitter A.
2. The receiver C.
3. The battery B, and finally of,
4. The conducting wires.

(*b*) The transmitter A is essentially a parallel-epipedic body of

17058

wood. Its upper part *u x* is cut out of one piece of square section, the side *z x* measuring 9 cm., its height *u x* 2.8 cm.

This part can be moved on the lower box A A by means of hinges. If we turn back the cover *x u* we shall notice a small circle cut out in it 3.9 cm. in diameter. A brass ring, with a margin 8 mm. broad, fits into this hole, which is furnished with a groove like a pulley.

Over the ring the membrane *m m* is stretched by a silk thread lying in the groove of the same. This circular membrane is surrounded by a wider circular hollow *b b*, 8.5 cm. A shovel-shaped strip of platinum *n s* is placed in connection with the brass binding post *d*, and rests by its circular piece *s* on the centre of the membrane.

By means of sealing-wax this circular part is fastened to the membrane, and is thereby compelled to accompany the membrane in its vibration. The farther transmission of the galvanic current from the centre of the membrane takes place by means of the brass angle *a s b* (D, Fig. 60). This rests at *s*, by means of a platinum or steel point, upon the conducting platinum strip *n s*, and dips at *b* with a platinum or steel point in a mercury cup, which is made in a screw transmitting the current. The point *a* serves only as a base or support for the angular piece *a s b*, which in general is supported like a tripod, in order that the contact point *s* should remain as constant as possible. The angle *a s b* is simply pushed over a projecting pin by a hole at *a*, uutil it remains resting on a broader lower part. From *b*, the electrical conductor with a covered wire extends to the brass key *e* (A, Fig. 60), and from there further in the direction indicated by the arrow.

The under part A A of the transmitter is constructed of wooden boards and form a parallel-epipedon whose height—6.8 cm., and whose breadth—7.7 cm. For the reception of tones there is the slanting attachment S made of tin with a funnel-shaped enlargement.

The longer side of this enlargement is 6.7 cm., the shorter 4.7 cm., the vertical diameter of the enlargement measures 7.15 cm., the horizontal diameter 7.5 cm., and finally the diameter of the narrower cylinder 3.9 cm.

It is plain, that if necessary, the platinum strip can be replaced by a thin strip of brass, and the platinum or steel points by iron ones. Only then the contact points must oftener be cleaned to a metal polish.

(*c*) The receiver is in general a double resonance box, whose

upper part, "the cover," is movable on two hinges and can be laid back. The length of this cover is 16.4 cm., its width 9.5 cm., and its height 3.2 cm. The length of the under box measures 22.9 cm., its width, 9.6 cm., and its height (98) 2.5 cm. The under part of the resonance box has two wooden bridges, which are separated from each other 7.4 cm., and serve as supports for the iron needle, which is 21.5 cm. long, and 0.9 mm. thick, and intended to produce the tones. The length of the spiral placed over the needle and designed for producing the electro-magnetism is 15. cm. The wooden covers of both parts must be constructed as thin as possible, and the greatest breadth of the circular holes seen in the figure measures 13 mm.

(*d*) One can successfully use as battery a small four-cell Smee's or two larger Bunsen's cells. The conducting line must be made at least so long that the exciting tones can no longer be heard through the wire. For corresponding between the two stations, the inventor has arranged the electro-magnetic telegraph apparatus *e v g h*, easily seen and understood from the figure. Agreement can be easily had as to the corresponding signals, and it is simplest to accept the signs given by the inventor. (26.)

The receiver C gives, on tapping with the key *e*, the corresponding signals by the rod *e e* giving out tones, while at the transmitter A the electro-magnet *v* announces the signals by means of the spring armature *z*.

53. Experiments with the telephone.

(*a*) As soon as one brings his mouth to the funnel S, and sings, the membrane of the transmitter A falls into corresponding vibrations, and the little iron rod *e e* at the second station begins to give out tones. Every time that a spark is visible at the first station, at *s*, the rod certainly sounds at the other station. The same is true when the peculiar buzzing tone is perceived, which arises from the striking of the vibrating platinum strip upon the point of the angular hook resting thereupon. The appearance of these sparks, or of the peculiar buzzing at the transmitter A, announces to the observers at the station A that the rod at C is giving forth tones. Tones and melodies, which were sung into the sound opening S, and especially clangs in which the teeth and head bones also vibrate (the so-called humming tones), always produce a toning of the rod or needle E E, and indeed, as already mentioned (S 51), without change of pitch, only with the reproduction of the rhythm of the respective song or words.

The pitch of the tone excited at C in the rod *e e* was, in the apparatus at my disposal, h': its strength not very remarkable and its quality (Klang) buzzing like that of the tone of a weak-sounding reed-pipe (something like a child's trumpet). The skin lying about the pericardium of the smaller and even the larger mammals (calves, etc.) makes the best membrane, gold-beater's skin reproduces only the lower tones.

The cover of the resonant box seemed superfluous in my apparatus, and the tone was indeed somewhat stronger without the cover.

1. In experiments with the telephone, close attention must be paid to seeing if the end *s* of the platinum strip still sticks to the membrane, and, if necessary, it must be pressed upon the membrane. When this leaf will no longer cling, a knife blade is heated, a piece of sealing-wax touched with it, and the melted wax thus transferred to the under side of the round end of the platinum strip *n s*. Immediately thereupon it is pressed on to the membrane *m m*.

2. From a long line of experiments, which I have performed with the telephone, I take the liberty of giving here some results:

(*a*) A Gagniard-Latour siren with upright axis, blown near the opening S from the lowest to the highest tone gave no result. Only when the rotating plate was turned directly toward the funnel-shaped sound receiver S, and brought very near the same, was it twice possible with the medium tones of the siren to hear two short tones of the iron rod *e e* of the pitch h^1.

(*b*) A tuning-fork with normal tone a^1 aroused no tone whatever in the receiver C, neither when in immediate vicinity of the sound funnel S, nor when laid upon it.

(*c*) A metal ball, which gave, according as it was rubbed with a strong bow, the tone h^1 or h^2, produced no results from the telephone, even when the bell was brought ever so near to the sound reed S, or when laid upon it. Only when the tone h^1, by means of suitable resonant tubes was very perceptibly strengthened, did the telephone respond weakly and shortly, and indeed again with h^1.

(*d*) Wooden lip pipes belonging to the scale between c^1 and c^2, when they were laid with the walls of their reeds on the sound funnel S and made to give out tones, were not able to bring the telephone to produce tones; but they were most active in respect to the telephone when the under open end of the reeds was brought immediately before or into the opening S of the sound cylinder of the transmitter A. This position may be called the "first."

These pipes also worked successfully upon the telephone when

their mouths (the holes) were laid on the sound-conducting opening S. This position may, from now on, be called the "second." If the pipes in both positions were removed only a few lines from the sound receiver S the effective vibration of the membrane ceased; and, in fact, in the first position sooner than in the second. If, however, pipes of any material of different length (1 ft. to over 8 ft.) and different widths, were laid on the conducting sound tube, and the former pipes applied to these in the first or second position, the telephone gave the same results as in the immediate use of the short transmitting tube.

(*e*) The former pipes, when covered, caused (as was to be foreseen) the telephone mostly not to sound at all, or only interruptedly in the first position. In the second position the telephone was excited by them for the most part completely, seldom interruptedly.

(*f*) I had at my disposal no pipes of the c^3 scale. Tones from the latter scale, which by strong blowing were excited in the pipes used by me, gave mostly no result, no matter what position was given to the pipe.

(*g*) A reed pipe of tone d^1 with open reed excited the rod of the telephone only when its open end was turned toward and brought near the sound receiving funnel S of the transmitter. Increasing the tone by a resonant tube produced an interrupted tone. A like result was obtained with a reed pipe of the tone c^1 with full beat reed only here the excited telephone tone was constantly interrupted.

(*h*) The miniature normal diapason (a small reed pipe of the tone a^1 compare Chap. VI.) sunk into the sound-conducting reeds, so that the mouth lay on the funnel, produced a clear tone in the telephone when strongly blown.

(*i*) Marches drummed at A with the key e e were produced by the receiver C, and, in fact, always with the tone h^1.

(*k*) Singing of different melodies was always successful; the rhythm of speaking was only interruptedly reproduced.

(*l*) Whistling with the mouth into S had no effect, and the tone passed over into a higher one, probably because the vibrating column of air thereby became shorter. The tones f^1, g^1, a^1, fis^1, c^1, and cis^1, produced with the month by whistling passed over into fis^1, gis^1, b^1, g^1, cis^1 and d^1 respectively, as soon as the mouth lay immediately before the sound receptor S.

There was a rise in the tone of half a tone.

Similar rise in tones is obtained by whistling into a cup, hat,

&c., indeed the cutting off of the current of air coming from the mouth by the flat of the hand raises the tone in such whistling, and this can be very easily recognized by moving the hand up and down.

(*m*) Since the distinct buzzing of the platinum strip on the transmitter S is a sure sign that the iron rod e e is sounding at C, there is no need in this respect of telegraphic communications between stations (S 52, d).

(*b*) If a comparison is made of the results of experiments with the telephone and those with the membrane phon-autograph it will seem at first as if the latter did much too little in comparison with the former. This contradiction, however, rapidly disappears. The membrane phon-autograph also gives plain tone writings of a melody in the space of an octave, together with double tones and chords, and according to Donders, still more. Moreover, in the telephone the membrane is moved not only by the vibrations of that tone, by which according to the laws of sympathetic vibration, it can be brought into vibration, but it is also mechanically raised and lowered by the strong condensations and rarefactions arising from the exciting tone (singing, &c.) In the closed masses of air. Every condensation will press the membrane outward, even when its deepest normal tone is much higher than the exciting (sung) tone. Very strong and thick membranes might perhaps resist this purely mechanical excitation, but they would be then not sensitive enough for real sympathetic vibration. In many cases (for example, in drumming with the key on the box, in placing the apparatus A on the resonant cover of the piano, &c.), the vibration of the membrane in the telephone arises also only in the same way as the membrane in Konig's pipes for proving notes of vibration (compare a latter paragraph). In this also, the stretching of the membrane is not necessary in order that the latter may show outwardly the condensations and rarefactions of the air in the pipe.

Pipes with thin walls furnish a farther proof of this. The latter allow trembling to be felt when touched by the hand while the pipes are sounding; indeed, very thin walls deepen the tone somewhat, and thereby show that they are not able to resist the pressure arising from the condensations.

Sand sprinked upon the walls of this kind is thrown off from the nodal points. If, therefore, thin strips of wood are able to imitate in such a manner the vibrations of the air in the pipe, although the proper tone of the wall may lie far from the exciting tone, this

is certainly much more the case with a membrane. The experiments with the pipes introduced in the previous paragraph also confirm this, for they only then gave a result in the telephone when the open end or mouth of the pipes lay very near the sound receptor, and even the experiments with singing confirmed this view. Just these experiments show the telephone weaker in comparison of the membrane-phonautograph because in the latter when the membrane is tuned for a tone, the tone writing comes, whatever position the exciting tone may have had in reference to the sound receiving side of the membrane-phonautograph, provided only it is near enough. And yet it would seem that to close the battery by means of the vibrating platinum strip on the membrane demands less strength than to move the little pen so that it may be able to remove the lampblack on the writing cylinder. The results of the few experiments with the telephone appear moreover to indicate that it might perhaps be more advantageous for the production of tone writing by means of the membrane phon-autograph, to make the latter of smaller dimensions than has been the case up to the present. In fact, Koning is already busy on new arrangements for the membrane phonautograph. Koning already hopes a better result for the written reproduction of simple sung melodies, if the wide opening of the paraboloid in the membrane phonautograph be closed by a plate, which had a small opening for applying the mouth.

In any case, a renewed study of the laws of the sympathetic vibrations of the membrane with a special reference to both pieces of apparatus will be necessary.

Many think that the membranes must vibrate sympathetically to every tone, because all the tones are heard by means of the membrane in the ear, but in this respect it is very important to note that, according to Prof. Mach (27), this may be brought about by a proper accommodation mechanism in the ear. For me this supposition of an accommodation, according to the varying tensions of the tympanum as a high degree of probability bordering on certainty.

Philip Reis showed his apparatus for the first time in October, 1861, in a very primitive form to the Physical Society at Frankfort-on-the Main ; on July 4th, 1863, to the same Society he showed the form represented in Fig. 60. This time he experimented over a distance of three hundred feet. Prof. Botger introduced the apparatus to the Naturforcher-Bersammlung, at Stettin (1863), in the Physical Section.

REIS PROSPECTUS—FROM PISKO.

Pisco's Neueren Apparate der Akustik, Wien, 1865, p. 241.

26. Here may be the place for the Prospectus which the inventor Mr. P. H. Reis attaches to the apparatus furnished by him and made by the artisan, Mr. Albert, in Frankfürt.

(Telephon). Every apparatus consists, as can be seen from Fig. 60, page 96, of two parts—the telephone proper and receiver C. These two parts are placed at such a distance from each other that the singing or toning of a musical instrument can be heard in no other way from one station to the other except through the apparatus.

Both parts are connected with each other, and with the battery B like common telegraphs. The battery must be sufficient to bring about at station A the attraction of the armature in the electromagnet fastened at the side (3-4 six inch Bunsen cells are sufficient for several hundred feet distant).

The galvanic current goes from B to the post *d*, from here through the copper strip to the platinum leaf on the middle of the membrane, then through the foot (at D, Fig. 60) of the angle to the screw *b*, in whose small hollow a small drop of mercury is placed. From here the current goes through the small telegraph apparatus *e*, *f*, then back to the key of the station C and through the spiral over *i* back to B.

If now sufficiently strong tones are produced in front of the sound-opening S, through the vibrations of the same, the membrane and the angular shaped little hammer lying upon it are set in vibration; the circuit is alternately opened and closed at every full vibration; and hereby are produced in the iron rod of the spiral at station C, the same number of vibrations, and these are perceived there as tone or tone combinations (accords). By laying the upper box tightly upon the axis of the spiral, the tones at C are very much strengthened.

Besides the human voice there can be produced (according to my experience), just as well the tones of good organ pipes from F—*c* and those of the piano. For the latter purpose A is placed upon the sounding board of the piano. (Of thirteen common chords an experienced experimenter could clearly recognize ten). As regards the telegraphic apparatus attached to the side, this is clearly unnecessary for the reproduction of tones, but it forms a very agreea-

ble addition for comfortable experimenting. By this it is possible to correspond right well, and surely with ones' vis-a-vis.

This takes place somewhat in the following simple manner:

After the apparatus is completely set up assurance is had of the continuity of the conductor, and the strength of the battery by opening and closing the circuit, when at A, the striking of the armature, and at C a very perceptible ticking of the spiral is heard.

By quickly alternately opening and closing at A, it is asked at C if they are ready for experimenting, whereupon C answers in the same manner.

Simple signals can by agreement at both stations be given by opening and closing the circuit once, twice, three times, or four times, for example:

1 stroke = sing.

2 strokes = speak, etc.

I telegraph words by numbering the letters of the alphabet, and then communicating their numbers:

1 stroke = a.

2 strokes = b.

3 strokes = c.

4 strokes = d.

5 strokes = e, etc.

Z would in this way be designated by 25 strokes.

This number of strokes would, however, waste time in representing and would be difficult to count surely, wherefore I place a dactyl stroke for every five strokes, then we have:

——00 for e.

——00 and 1 stroke for f, &c.

Z ——00——00——00——00——00, which is more quickly and easily carried out, and better to understand.

It is still better to designate the letters by numbers which are inversely proportional to the frequency of their recurrence.

Dolbear, pages 601–603.

2066

(No. 8.) Defendants' Exhibit, Ferguson's Description of Reis.

Extract from Publication Entitled "Electricity," by ROBERT M. FERGUSON, *London*, 1867. *Page* 257.

J. A. W., Sp. Ex'r.

[Introduced in Record, page 6.]

THE TELEPHONE.—This is an instrument for telegraphing notes of the same pitch. Any noise producing a single vibration of the air, when repeated regularly a certain number of times in the second (not less than 32), produces, as is well known, a musical sound. In Art. 115, we found that when a rod of iron was placed in a coil of insulated wire, and magnetized by a current being sent through the coil, it gave out a distinct tick when it was demagnetized by the stoppage of the current. A person when singing any note causes the air to vibrate so many times per second, the number varying with the pitch of the note he sings, the higher the note, the greater being the number of vibrations. If we then, by any means can get these vibrations to break a closed circuit in which the coil just mentioned is included, the note sung at one station can be reproduced at least so far as pitch is concerned, and another. Reis' telephone (invented 1861) accomplishes this in the following way:

A A (Fig. 141), is a hollow wooden box with two round holes in it, one on the top, the other in front. The hole at the top is closed by a piece of bladder S, tightly stretched on a circular frame; a mouth piece M is attached to the front opening.

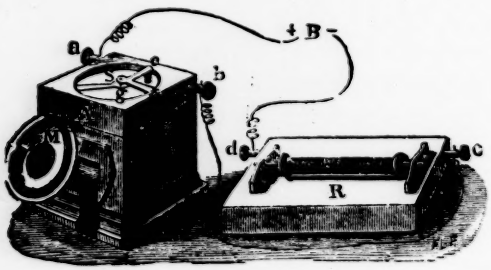


FIG. 141.

When a person sings in at the mouth-piece, the whole force of

his voice is concentrated on the tight membrane, which in consequence vibrates with the voice. A thin strip of platinum is glued to the membrane, and connected with the binding screw *a*, in which a wire from the battery B is fixed. A tripod *e f g*, rests on the skin. The feet *e* and *f* lie in metal cups on the circular frame over which the skin is stretched. One of these *f*, rests, in a cup containing mercury, and is connected with the binding screw *b*. The third foot *g*, consisting of a platinum point, lies on the circular end of the strip of platinum just mentioned. This point, being placed on the centre of the oscillating membrane, acts like a hopper, and hops up and down with it. It is easy to understand how, for every vibration of the membrane, the hopper will be thrown up for the instant from connection with its support, and how the close circuit is thus broken at every vibration. The receiving apparatus R consists of a coil of wire placed in circuit, enclosing an iron wire, both being fixed on a sounding box. The connections of the various parts of the circuit are easily learned from the figure. Suppose a person to sing a note at the mouth-piece which produces three hundred vibrations a second, the circuit is broken by the bladder three hundred times, and the iron wire ticking at this rate gives out a note of the same pitch. The note is weak, and in quality resembles the sound of a toy trumpet. Dr. Wright uses a receiving apparatus of the following kind: The line current is made to pass through the primary coil of a small induction coil. In the secondary circuit he places two sheets of paper silvered on one side, back to back, so as to act as a condenser. Each current that comes from the sounding apparatus produces a current in the secondary circuit which charges and discharges the condenser, each discharge being accompanied by a sound like the sharp tap of a small hammer. The musical notes are rendered by these electric discharges, and are loud enough to be heard in a large hall.

2168

(No. 9.) Defendants' Exhibit, "The Telegrapher," published in New York in 1869, Vol. 5, No. 39.

J. A. W., Sp. Exr.

[Introduced in Record, page 6.]

(This is a REPRINT of DR. VAN DER WEYDE'S ARTICLE IN "THE MANUFACTURER AND BUILDER" for May, 1869. See No. 10.)

(No. 10.) Defendants' Exhibit, "The Manufacturer and Builder," New York, May, 1869, Vol. 1, No. 5, pages 129–130.

J. A. W., Sp. Exr.

[Introduced in Record, page 6.]

THE TELEPHONE.

One of the most remarkable recent inventions connected with telegraphy is the telephone, an instrument which transmits directly the pitch of a sound by means of a telegraph wire—either an air wire or submarine cable; so that, for instance, when the operator at one end of the wire sings or plays on an instrument any tune, as "Yankee Doodle," or "Hail Columbia," it will be heard and distinguished plainly at the other end. This invention may, in its present state, have no direct practical application, but be a mere scientific, although highly interesting curiosity; but who can say that it does not contain the germ of a new method of working the telegraph, or some other useful practical purpose? The telephone is not the result of an accidental discovery, but of a thorough study of the laws of electro-magnetism and of sound. It is founded on the fact that the difference in pitch of different tones is caused by different velocities of vibrations of the elastic-sounding body; which vibrations are transmitted to and by the air with exactly the same velocity, and from the air may be communicated to a properly stretched membrane, like a piece of bladder or very thin sheet of india rubber, stretched like a drum head, which these also will vibrate with exactly the same velocity as the air and the original sounding body, be it the human voice, organ pipe, string, or any musical instrument, if, now, at the centre of this little drum head there be attached a small disk of some metal not easily burned by electric currents—for instance, platinum—while at the same time a platinum point may, by means of a screw, be so adjusted as to come very nearly in contact with this small platinum disk, it is clear that when the membrane is put in vibration a succession of contacts between the disk and point will be produced, of which the number in each second will exactly correspond with the number of vibrations in each second of the sounding body, or the tone produced by it. That part of the apparatus which serves to send off the tune or melody is represented in the illustration, Fig. 2. It consists simply

2070

of a square wooden box, provided at the side with a kind of mouthpiece similar to that of a speaking tube, and at the top with an opening, over which the membrane just mentioned has been stretched. The small disk of platinum attached to the centre of this little drum head is, by means of a very flexible strip of some metal that conducts well attached to one pole of the galvanic battery, of which only one cup is represented in the figure, although for a long wire several cups will of course be required. The reason why this connection near the platinum disk is a flat, thin and flexible strip is, that any rigidity would interfere with the freedom of vibration of the membrane to which it is attached. The point coming in contact with this small vibrating disk is connected with ground wire, the other pole of the battery with the air wire or submarine cable. It is clear, from this explanation, that at every contact of the platinum point a wave of electricity will be sent over the wire, and as many waves in a second as there are contacts; and as there are as many contacts as there are vibrations in every second, the number of electric waves will be always exactly equal to the number of vibrations corresponding with the pitch of each tone, be it fifty, one hundred, two hundred, or five hundred in every second.

The instrument in which this succession of waves is made audible at the other end of the telegraph wire is founded on fact, first investigated by Professor Henry, of the Smithsonian Institute, at Washington, that iron bars, when becoming magnetic by means of electric currents passing around them, become slightly elongated, and at the interruption of the current are at once restored to their original length. It is represented in the cut, Fig. 3, and consists of an elongated wooden box, of which the top is made of thin pine wood, similar to the sounding board of a stringed musical instrument, to which are attached two bridges carrying long pieces of moderately thick and very soft iron wire, which for nearly their whole length are surrounded by a coil similar to the coil of the electro-magnets used in telegraphing. One end of this coil is attached to the telegraph wire, the other to the ground wire, as represented in the figure. At every instance that a contact is established at the station where the sound is produced, and a current wave thus transmitted, these wires will become magnetic, and consequently elongated, and they will be shortened again at every interruption of the current; and as these currents and interruptions succeed each other with the same velocity as the sound vibrations, the elonga-

tions and shortenings of the magnetized iron wires will succeed each other with exactly the same velocity, and consequently they will be thrown into a state of longitudinal vibrations corresponding with the original musical tone, which vibrations will then be communicated to the sounding board in exactly the same manner as is the case with the vibrations of the strings in all stringed instruments, thus becoming more audible at the receiving station.

It is clear, from the foregoing explanation, that no quality of tone can be transmitted. Much less can articulate words be sent, notwithstanding the enthusiastic prediction of some persons, who, when they first beheld this apparatus in operation, exclaimed that now we would talk directly through the wires. It is, from its nature, able to transmit only pitch and rhythm, consequently melody and nothing more. No harmony, nor different degrees of strength or other qualities of tone can be transmitted. The receiving instrument, in fact, sings the melodies transmitted, as it were, with its own voice, resembling the humming of an insect, regardless of the quality of the tone which produces the original tune at the other end of the wire. This instrument is a German invention and was first exhibited in New York at the Polytechnic Association of the American Institute, by Dr. Van der Weyde. The original sounds were produced at the further extremity of the large building (The Cooper Institute), totally out of hearing of the Association, and the receiving instrument, standing on the table of the lecture room, produced, with its own rather nasal twang, the different tunes sung at the other end of the line, rather weakly, it is true, because of the weak battery used, but very distinctly and correctly.

(No. 11.) Defendants' Exhibit, Baile's Article.

The Wonders of Electricity. Translated from the French of J. Baile. New York: Scribner, Armstrong & Co. 1872.
pp. 140–143.

J. A. W., Sp. Exr.

[Introduced in Record, page 6.]

Wonderful as are these achievements, the inventions in telegraphy have gone still further. To be able to transmit thought to a distance is a triumph which was formerly astonishing; but we are now accustomed to it, and continue to practice it without its creating the slightest wonder. To be able to transmit handwriting, and even drawings, appeared to be still more difficult; but this problem has also been resolved, and we now hardly wonder that this feat is accomplished by means so simple. Mankind ever requires a new stimulus to its curiosity, and already it is looking forward to the discovery of more marvels in telegraphy; some years hence, for all we know, we may be able to transmit the vocal message itself, with the very inflection, tone and accent of the speaker. Already has the acoustic telegraph been invented; the principle has been discovered, and it only remains to render the invention practicable and useful—a result which, in these days of science, does not appear to be impossible.

Sound, of whatever kind, is produced by a series of vibrations, more or less rapid, which, setting out from a sonorous body, traverse the air and reach our ear. Just as a stone, dropped into a pond, throws off a succession of circular undulations or water rings, so a concussion, acting on the air, produces analogous vibrations, though they are invisible; and it is when these vibrations reach the ear that we become sensible of sound.

An eminent scientific German, M. Helmholtz, has analyzed the human voice and determined its musical value; according to him, each simple vowel is formed by one or more notes of the scale, accompanied by other and feebler notes which are harmonics of these. He demonstrates that it is the union of all these notes that give quality to the voice. Each syllable is formed by the notes of the vowel, accomplished by different movements of the organs of the mouth. M. Helmholtz, reflecting upon this, thinks it would be pos-

sible to construct a human voice by artificially producing and combining the elementary sounds of which it is composed.

This is not the place to discuss such theories, but if we grant that there is any truth in them, we can understand that the acoustic telegraph can be invented and can transmit the living voice. Already experiments have been made in this direction. A vibrating plate produces a sound and, according to the rapidity of the vibrations, these sounds are sharp or flat. At each of the vibrations the plate touches a small point placed in front of it, and this contact suffices to throw the current into line; when the plate ceases to vibrate and returns to its position of equilibrium, it no longer touches the metal point and the current is consequently interrupted. By this means is obtained a series of interruptions, more or less rapid, according to the sound, the current being thrown into the line and interrupted once for each of the vibrations. At the extremity of the line the current enters an electro-magnet, which attracts another vibrating plate of size and quality identical with the former. Attracted and repelled very rapidly, exactly and as rapidly in fact as the plate mentioned above, this second plate gives forth a sound which will have the same musical value as that of the other, as the number of vibrations per second is the same in both cases.

Should this process be perfected, it will be possible to transmit sounds by means of the telegraph—to transmit a series of sounds, a tune, or spoken sentence, and conversation. This consummation has not, however, been yet attained. Many experiments have been made, the principle has been applied in divers ways, and everything makes us hope that we will yet arrive at a perfect system of acoustic telegraphy. Advances have been made very far upon the road to success. A series of vibrating plates, answering to the strings of a harp, has been arranged, each of which vibrates when struck by a particular sound, and sends off electricity, to create at the end of the line the same vibrations in a corresponding plate; or, in other words, to produce the same sound.

This system, it must be admitted, is at least very ingenious. Experiments have been made in laboratories, that is to say, under conditions entirely favorable, and such as we would not often find in actual practice. Under these conditions a musical air has actually been successfully transmitted by this acoustic telegraph. All must admit that this is a promising beginning, but we must not make too much haste to exalt the miracle and to extol the advantages of the future machine, or to abandon ourselves to the indulgence in indis-

2074

criminate laudation on the strength of this new discovery. That would be a gross mistake and an injury to science. True scientific faith is doubt until the truth appears in uncontrovertible clearness. Care must be taken not to take for reality that which is merely a desire on our part. We must guard against all premature exultation, because it weakens us in the search for truth, and because even one deception is cruel. Let us therefore give to doubt, to patience and to perseverence the place which some too readily give to congratulation.

(No. 12.) Defendants' Exhibit, Bottger's Account of Reis Improved Apparatus.

Dingler's Polytechnic Journal, Vol. 169, p. 399.

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 6.]

CONCERNING THE IMPROVED TELEPHONE.

In the meeting of the Physical Society, held on July 4th, at Frankfort a-M., a member of the society, Mr. Philip Reis, from Friedrichsdorf, near Homburg before the Heights, exhibited some of his improved telephones (apparatus for the reproduction of tones at any desired distance by means of the galvanic current). It is two years since Mr. Reis first gave publicity to his apparatus, and, although the performances of the same, in their simple, primitive form, were astonishing, yet they had this great defect, that experimenting with the same was possible only for the inventor. The instruments exhibited in the above-mentioned meeting scarcely reminded one of the earlier forms.

Mr. Reis has striven to give the same a form pleasing to the eye, so that they now will worthily fill a place in every physical cabinet. This new apparatus can now be easily managed (worked) by every one, and works with great certainty. Melodies sung quite lightly, at a distance of about three hundred feet, were reproduced by the instrument, set up much more distinctly than formerly. The musical scale was especially sharply reproduced.

The experimenters could even reproduce words, although, indeed, only such as had been often heard by them.

In order, now, that others, less experienced, may be able to even make themselves understood through the apparatus, the inventor has fixed at the side of the same a small, yet, according to his explanation, entirely sufficient arrangement, whose speed of communication, indeed, is not so great as that of the more recent telegraphs, but which works very surely, and assumes no especial skill in the person working it. We would call the attention of gentlemen busying themselves with physics to the fact that the inventor now has this interesting apparatus manufactured for sale under his supervision (the principal [important] parts he makes himself), and the same can be had of him directly or through the instrument maker, Wilhelm Albert, at Frankfort-on-the-Main, in two qualities, differing only in outward finish, at fourteen and twenty-one florins, respectively (Bottger's Polytechn. Notizblatt, 1863, No. 15).

2076

(No. 13.) Defendants' Exhibit, Cosmos Description of Reis.

"Cosmos," Vol. XXIV., pages 349, 352. Printed and published at Paris, March 22, 1864.

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 6.]

GENERAL PHYSICS: ACOUSTICS.

The Acoustic Telegraph or Telephone of Mr. Philip Reis.

In 1837 Mr. Page observed for the first time the phenomenon of the production of sound by electricity, when the poles of a magnet were rapidly brought near to and moved away from a helix or conducting wire, through which an electrical current was passing. M. Delezenne produced an analogous effect by turning an armature of soft iron before the poles of a magnet. The particular phenomenon with a helix was observed separately by M. de la Rive and MM. Beatson and Marriani. Each of these physicists made upon this subject their own special remarks. M. de la Rive attributed the sound produced to the kind of shock which took place upon the sudden displacement of the molecules at the moment when the current produced its appropriate action. It would therefore be possible to increase the intensity of the effect produced by multiplying the intermittances in the passage of the current. It is in this way that the learned professor of Geneva was able to produce a sound both clear and prolonged, from a cylindrical mass of iron ten centimetres in diameter and weighing ten kilogrammes. M. Marriani recognized on his part that the sound created by a bar of iron placed in these conditions was the same as that which it would give forth if it was thrown into vibration by blows which affected it at its extremity. None of the magnetic metals produced any effect of the kind. As to the coercitive force, M. Marriani establishes that a bar of steel, well tempered, would make no sound, but that on the contrary the phenomena manifested itself when it was annealed. M. Marriani and M. de la Rive observed also that an intermittent current passed through a stretched wire made it produce a sound identical with that which it would give forth if it were placed in the interior of a helix. According to M. de la Rive, the sound was

more intense as the wire was made shorter, and according as its electrical resistance came nearer to that of the battery employed.

M. Wertheim rendered sensible to the ear the vibrations which result from the passage of a discontinuous electric current through a rigid bar.

In these various experiments, in addition to the musical sound, the observer perceived a succession of blows (battement) which coincided with the interruptions of the current. M. de la Rive compared them to the noise which drops of rain made on falling upon a metal roof. These successive blows would even be obtained on operating upon magnetic metals reduced to a powder. M. de la Rive explains this: The sound produced by iron when the current passes in the magnetizing helix is explained by M. de la Rive as follows:

"The current tends to place the molecules of the iron in a longitudinal direction. These tend to return afterwards to their normal position, hence the vibrational movement which gives rise to the sound."

It is on the basis of these facts that Mr. Reis has constructed the telephone or acoustic telegraph. Fantastic minds have singularly exalted the qualities of this apparatus. They have undertaken to indicate for it at once an office which it is far from being able to fill. The exaggerations of these illusions have been demonstrated to us by experiments which we have just made at Mr. Koenig's establishment with an apparatus constructed in Germany, under the supervision of Mr. Reis. This physicist has constructed his telephone in the following manner:

The transmitter (manipulator) is represented by a rectangular hollow box. One of the sides of this is provided with a flaring opening, intended to receive the note which was to be transmitted. The upper surface of it consists of a membrane, suitably stretched, on the centre of which is fixed a strip of platinum, which is in electrical connection with one of the poles of the battery. Above this there is placed a second and movable strip which, when the instrument is not in operation, rests on the first by a fine point, making contact by a fine point, also of platinum. It will readily be understood that if the membrane vibrates it will throw up into the air the movable strip, which will again fall back into place. Hence, oscillations which will correspond in number exactly with those of the membrane. The receiver is composed simply of a magnetizing helix, in the interior of which is placed a bar of soft iron. The

1208

whole is mounted on a resonating box. When the apparatus is to be operated, these two instruments are placed in the circuit with an ordinary line battery. The operation of the instrument is easy to understand. The vibrations which the operator placed in front of the mouth-piece impresses upon the air enclosed in the box of the transmitter are repeated by the membrane; and just as a style fixed on this membrane (as in the phonautograph) would write these vibrations upon a paper covered with lamp-black, so in the same manner the electrical contacts are successively established and broken between the two strips of platinum. Hence, there is caused in the coil of the receiver a number of intermittances or interruptions in the passage of the current, which is necessarily equal to the number of vibrations of the membrane of the transmitter. Now, since each intermittation causes one single shock, a series must necessarily produce a sound identical in pitch with that produced at the mouth-piece of the transmitter. Would not the telephone of Mr. Reis be an admirable instrument if it realized absolutely the promises which its theory holds out? Without prejudging the future, we must recognize that it has not yet done so. When one sings the musical scale of the transmitter, there needs an ear well trained to distinguish the sounds repeated by the receiver in the midst of the vibrations which agitate it. For ourselves, we have been only able to recognize the success of rise and pitch of these rapid roulades; but perhaps a trained musician would be able to recognize amongst them a dominant note. The model, however, of which we speak, did not, and had in its construction several causes of error; and Mr. Koenig, so justly recognized in matters of acoustics, intends to study out the improvements of which this telephone is susceptible.

Let us mention some of the principal of these causes of error: It may be that the membrane will not at every moment vibrate with the same degree of amplitude, and this will consequently occasion sometimes a failure to make contact; if the sound produced by the operator at the transmitting end does not vary much, the contact may be prolonged; the remedy for this defect is in substituting for the voice of the operator a tuning fork, arranged to vibrate, for example, by a battery; then a note would be produced which would be better defined but always very feeble. As to improvements which would be of a nature to render this telegraphic apparatus practicable, Mr. Koenig is well fitted to find them. We already know certainly that the intensity of the sound increases as a softer iron is used,

because in that case the molecules have more freedom of motion than they had in the hardened iron or in steel. If the iron core is magnetized by the influence of a permanent magnet, or by another coil, its sound is more intense when the intermittent current is sent in such a direction as to produce a demagnetizing effect upon it, and it is less intense when the current is sent through the helix in such a direction as to increase the magnetism. The reason is, that in this last case the molecules are in advance, in a position already very near that which the current can compel them to take. Too much tension in the core also makes the sound more feeble, for the molecules having been already placed in a forced position, are less free to receive further motion. The electrical transmission of musical sounds is therefore a problem, of which the true solution has not been found; and all the magnificent promises which have been made and published on the subject of acoustic telegraphy seem to us still to belong to the region of illusions.

2080

(No. 14). Defendants' Exhibit, Koenig's Description of Reis.

From Koenig's "Catalogue des Appareils d'Acoustique, Paris, 1865, page 5.

J. A. W., Sp. Ex'r.

[Introduced in Record, page 6.]

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29. TELEPHONE OF M. REIS. 60 FR.

This apparatus is intended to transmit sounds to a distance by means of electricity. It rests upon the fact demonstrated by the preceding apparatus. (*The preceeding apparatus was the Wertheim coil and core, which Reis uses for a receiver.*)

At the first station the current traverses a little band of platinum, which is attached to a membrane in such a way as to follow all its movements, and of a very movable point, which rests lightly upon this membrane. At the other station the current traverses a coil, at the center of which is a bar of soft iron. If now we produce before the membrane a sound which causes it to vibrate, each vibration in pushing away the point from the platinum plate will produce an interruption of the current. On the other hand, each making of the current will produce in the bar of soft iron at the second station a momentary and weak sound. It is the rapid and isochronous succession of these sounds, all acting as simple blows, which produce the continuous sounds that are heard. It is true that they are not of good quality and that they cease from time to time. This comes from the fact that the membrane does not vibrate equally well for all tones, and because the manner in which the vibrations determine the interruption of the current, by pushing the little point away from the plate, is far from being perfect.

(No. 15.) Defendants' Exhibit, Du Moncel's Bourseul, 1881

J. A. W., Sp. Ex'r.

[Introduced in Record, page 6.]

Du Moncel's Exposé des applications de l'Electricité, Vol. 2, p. 225, Edition 1854; Vol. 3, p. 110, Edition 1856, contains the following:

"*Electric Transmission of Speech.* I have not been willing to give a place in the chapter on electric telegraphy to a fantastic conception of a certain Mr. Ch. B**, who believes that we may yet be able to transmit speech by electricity, because I might have been asked why, by the side of so many remarkable inventions, I was willing to class an idea which, as presented by its author, has not got beyond the condition of a dream. But I have undertaken to mention all of the applications of electricity which have come to my knowledge, and therefore I will here give the information which the author has published up to this time on the subject.

"After the telegraphic marvels, which can reproduce at a distance handwritings, or even more or less complicated drawings, it may appear impossible to penetrate farther into the region of the marvelous, yet we will try to advance a few steps farther. I have, for example, asked myself whether speech itself may not be transmitted by electricity; in a word, if what is spoken in Vienna may not be heard in Paris? The thing is practicable in this way:

"We know that sounds are made by vibrations, and are made sensible to the ear by the same vibrations which are reproduced by the intervening medium. But the intensity of the vibrations diminishes very rapidly with the distance; so that even with the aid of speaking-tubes and trumpets, it is impossible to exceed somewhat narrow limits. Suppose that a man speaks near a movable disk, sufficiently flexible to lose none of the vibrations of the voice; that this disk alternately makes and breaks the currents from a battery; you may have at a distance another disk which will simultaneously execute the same vibrations.

"It is true that the intensity of the sounds produced will be variable at the point of departure, at which the disk vibrates by means of the voice, and constant at the point of arrival, where it vibrates by means of electricity; but it has been shown that this

does not change the sounds. It is, moreover, evident that the sounds will be reproduced at the same pitch.

"The present state of acoustic science does not permit us to declare *a priori* if this will be precisely the case with syllables uttered by the human voice. The mode in which these syllables are produced has not yet been sufficiently investigated. It is true that we know that some are uttered by the teeth, others by the lip, &c., but that is all.

"However this may be, observe that the syllables can only reproduce upon the sense of hearing the vibrations of the intervening medium. Reproduce precisely these vibrations and you will produce precisely these syllables.

"It is, at all events, impossible, in the present condition of science, to prove the impossibility of transmitting sound by electricity. Everything tends to show, on the contrary, that there is such a possibility. When the application of electro-magnetism to the transmission of messages was first discussed, a man of great scientific attainments treated the idea as Utopian, and yet there is now direct communication between London and Vienna by means of a simple wire. Men declared it to be impossible, but so it is.

"It need not be said that numerous applications of the highest importance will immediately arise from the transmission of speech by electricity. Any one who is not deaf and dumb may use this mode of transmission, which would require no apparatus except an electric battery, two vibrating disks and a wire. In many cases, as for example in large establishments, orders might be transmitted in this way, although transmission by electricity will not be used while it is necessary to transmit letter to letter, and to make use of telegraphs which require use and apprenticeship. However this may be, it is certain that in a more or less distant future speech will be transmitted by electricity. *I have made some experiments in this direction.* They are delicate, and demand time and patience; but *the approximations obtained* promise a favorable result."

(No. 16.) Defendants' Exhibit, Didaskalia Bourseul Article.

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 7.]

DIDASKALIA, Sept. 28, 1854.

The wonders with which electricity has lately astonished us are about, as it seems, to be increased by a new one, that would not only prepare a great revolution in the electric telegraph as practiced up to the present, but would increase its usefulness in an incalculable manner.

It is a question of nothing more nor less than an electric transmission of *the spoken word*. The idea originates with a young and educated, though modest young man, Charles Bourseul, who was a soldier of the African army in 1848, where he attracted the attention of the Governor-General by a mathematical course which he delivered to his comrades of the garrison in Algeria, and he is now living in Paris. Bourseul's problem of the practicability of which he is completely persuaded, belongs, perhaps, to those discoveries which the scientific world afterwards declares very easy, and which they would gladly make us believe could easily have been discovered much earlier if they had chosen to give themselves the trouble.

As is well-known, the principle upon which electric telegraphy is based, is as follows: An electric current traversing a metallic wire changes a piece of soft iron in the vicinity of which it passes into a magnet. As soon as the current ceases, the magnetic quality also ceases. This magnet, the electro-magnet, can thus alternately attract or let go a movable plate, which by its movements back and forth produces the conventional signals used in telegraphy. Now it is farther known that all tones are brought to the ear only by vibrations of the air, hence are really nothing more than these vibrations of the air, and that the endless variety of tones depends entirely upon the rapidity and amplitude of the sound waves.

Could there now be invented a metallic plate which should be so movable and pliable that it reproduces all the vibrations of tones (like the air), and should this plate be so connected with an electric current that it should alternately make and break the electric current according to the air vibrations by which it was affected, it would thereby be possible also to arrange electrically a second similarly

1887

does not change the sounds. It is, moreover, evident that the sounds will be reproduced at the same pitch.

"The present state of acoustic science does not permit us to declare *a priori* if this will be precisely the case with syllables uttered by the human voice. The mode in which these syllables are produced has not yet been sufficiently investigated. It is true that we know that some are uttered by the teeth, others by the lip, &c., but that is all.

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[Introduced in Record, p. 7.]

DIDASKALIA, Sept. 28, 1854.

The wonders with which electricity has lately astonished us are about, as it seems, to be increased by a new one, that would not only prepare a great revolution in the electric telegraph as practiced up to the present, but would increase its usefulness in an incalculable manner.

It is a question of nothing more nor less than an electric transmission of *the spoken word*. The idea originates with a young and educated, though modest young man, Charles Bourseul, who was a soldier of the African army in 1848, where he attracted the attention of the Governor-General by a mathematical course which he delivered to his comrades of the garrison in Algeria, and he is now living in Paris. Bourseul's problem of the practicability of which he is completely persuaded, belongs, perhaps, to those discoveries which the scientific world afterwards declares very easy, and which they would gladly make us believe could easily have been discovered much earlier if they had chosen to give themselves the trouble.

As is well-known, the principle upon which electric telegraphy is based, is as follows: An electric current traversing a metallic wire changes a piece of soft iron in the vicinity of which it passes into a magnet. As soon as the current ceases, the magnetic quality also ceases. This magnet, the electro-magnet, can thus alternately attract or let go a movable plate, which by its movements back and forth produces the conventional signals used in telegraphy. Now it is farther known that all tones are brought to the ear only by vibrations of the air, hence are really nothing more than these vibrations of the air, and that the endless variety of tones depends entirely upon the rapidity and amplitude of the sound waves.

Could there now be invented a metallic plate which should be so movable and pliable that it reproduces all the vibrations of tones (like the air), and should this plate be so connected with an electric current that it should alternately make and break the electric current according to the air vibrations by which it was affected, it would thereby be possible also to arrange electrically a second similarly

2084

constructed metal plate, so that it repeated simultaneously exactly the same vibrations as the first plate, and it would then be exactly the same as if one had spoken in the immediate vicinity against this second plate, or the ear would be affected precisely as if it received the tones directly through the first metallic wall. The electric telegraph formerly stamped by the academy as nonsense, is now spread throughout all the world as a common phenomenon; if we question in regard to this new idea of a young physicist the principles of physics, they have not only nothing to offer against the possibility of its being carried out, but its success appears in fact, to be more probable than did a short time ago that of the electric telegraph itself. If it be practically carried out, the electric telegraph could be operated by every one. There would be need of no farther device and knowledge than a galvanic battery, two vibrating plates and a metal wire; without any other preparation the one must talk against one metallic plate, and the other hold his ear near the other plate, and they could converse with each other as if face to face. The young inventor believes in the success of his efforts, and challenges scientific men to prove that the laws of physics contradict the above-mentioned principles, and thereby, make the attempt seem impossible. Meanwhile, may the affair enjoy in high degree, the attention which it is certainly attracting,

"Didaskalia Magazine for Intelligence, Humor and News," No. 232. 28th of September, 1854. Translated by A. Stetson.

2685

(No. 16a.) Defendants' Exhibit, Extracts from "Didaskalia," as printed in a publication entitled "Phillip Reis, Inventor of the Telephone," by Sylvanus P. Thompson, B. A. D., &c., pp. 66--68.

[Introduced in Record, p. 7.]

TRANSLATION FROM "DIDASKALIA," May 8th, 1862.

The excellent physicist, Mr. Phil. Reis, of Friedrichsdorf, calls by this name his surprising invention for using the telegraph line to transmit really audible tones.

Our readers will, perhaps, remember having heard some time since of this invention, the first trials with which Mr. Reis performed here in the Physical Society. Since then the invention has been constantly developed, and will no doubt, become of great importance.

TRANSLATION FROM "DIDASKALIA," 12th May, 1862.

Yesterday's meeting of the free German Institute was a very numerously attended one from the fact that the subject in the order of business, "Telephony by Transmission of the Galvanic Current," as explained by the inventor himself, Mr. Phil. Reis, excites so great an interest that it rightly deserves the most general attention.

In a lecture exceedingly interesting, universally understood, clear and concise, Mr. Reis gave a historical outline of the origin and development of his idea of the practical possibility of the transmission of tones in a galvanic way.

His first attempts were mostly unsuccessful in solving the cardinal question propounded by him. "How is it possible that a single instrument can reproduce at once the total action of all the organs operated in human speech?" Until finally it occurred to him to seek the solution of the problem in the question, "How does our ear take cognizance of the total vibrations of all the organs of speech acting at once?" or "How do we perceive the vibrations of several bodies sounding at once?"

In order to answer this question the lecturer went more closely into the anatomy of the ear and into the formation of tones in general. After this was determined, he took up again his experiments in reference to the transmission of tones by means of galvanism.

Afterwards Mr. Reis constructed, considerably enlarged, the parts

2056

of the ear necessary for hearing, by which it was finally possible for him to transmit the tones brought to the mechanically imitated ear.

The experiments by him some months ago in the Physical Society, were, to the astonishment of all, exceedingly plain and clear, whereas the experiment following the lecture of yesterday was less successful. This was due partly to the poor conductivity of the wires, partly to the locality.

Although much is still left to be done for the practical utilization (Verwertthung) of the telephone, yet a new and interesting field of labor is hereby opened to physics.

(No. 17.) Defendants' Exhibit, Report of Reis Lecture.

Frankfurter Conversationsblatt, Nov. 29th, 1861.

J. A. W., Sp. Ex'r.

[Introduced in Record, page 7.]

Reproduction des Schalles durch den Galvanischen Strom. (*Frankfurt.*)

"*Reproduction of Sound by the Galvanic Current.*" (*Frankfort.*)

For this new discovery, which rightly excites the greatest interest, we have to thank Mr. Reis, teacher in Friedrichsdorf. He has succeeded, after many experiments, in solving, up to a certain point, at least, this problem, which up to the present has been considered insolvable.

Of all the new discoveries in natural science there are none of so general advantage, and which so enter into our practical life, as those in the domain of chemistry and physics; in the latter, galvanism, in its application to electro-plating and telegraphy, has achieved remarkable results. At the moment when telegraphy has attained a place in our social life, there begins, perhaps, for the same a new era in the fact that as we in telegraphy make ourselves understood by means of signs, in this we can make ourselves understood by means of tones at a distance.

Mr. Reis has constructed in a very ingenious manner an apparatus by means of which he has shown some perfectly successful experiments befo: a large audience in the Physical Society in this city.

He has made a very happy use of the earlier discovery that the iron core of a wire helix produces tones by the interruptions of the current following each other at very short periods.

His apparatus for receiving the sound is based upon the arrangement of the human ear. It consists in the first place of a funnel-shaped cavity (to represent the cartilage of the ear) to receive the sound, closed at its narrower part by a membrane, upon which is fastened an elastic strip of platinum, which is connected with one of the circuit wires, while the former is in electric connection with the other pole of the battery.

As soon, then, as the sound waves set the membrane in vibra-

tion, the elastic strip of metal fastened to the same will make the same vibrations—will alternately rise and fall, thereby touching the other elastic strip, and so making and breaking the current.

The reproduction of the sound by the galvanic current, for it is only such, and not a conduction of the sound, is brought about in the manner specified above. Into a wire helix, included in the circuit, is placed a thin metal rod—*e. g.*, a knitting needle—which apparatus, in order to increase the tone, is placed upon an easily-vibrating support, a resonant box. By means of the current now made, now broken, the iron rod is also set into vibrations, which are communicated to our ear and there reproduce the sound.

The vibrations of the iron rod correspond with those of the membrane; but as the pitch of the tones is dependent upon the times of vibration of the sounding body, the lower tones escape our notice, while the higher ones are especially noticed.

Up to the present the reproduction of the tones is indeed weak, and words cannot be reproduced. We leave here the question as to whether this hereafter will be successfully accomplished.

Mr. Fritz, instrument maker, has just constructed a new instrument with some improvements, and Prof. Doettger will hereafter make experiments with it in the Physical Society, to which we shall at times call attention.

(No. 18.) Defendants' Exhibit, Reis Exhibition of 1861.

1059

Fortschritte der Physik, xvii., for 1861, pp. 171–3.

J. A. W., Sp. Exr.

[Introduced in Record, p. 7.]

PH. REIS. *Telephony by means of the electric current.* (*Annual Report of the Physical Society of Frankfort-on-the-Main, 1860–1, pp. 57–64*).

By the name "Telephone" the author designates the following apparatus of his own construction, by means of which and with the help of the galvanic current he is enabled "to reproduce at a distance the tones (tonen) of different instruments, and even, to a certain degree, the human voice."

A wooden cube is bored through from one of the faces to the opposite one, the cavity taking the shape of a cone; the smaller opening is closed by means of a membrane (hog's intestine, schweinsdunndarm). On the middle of the membrame, and parallel with it, is a thin strip of platinum, cemented fast at one end, whilst the other end is held by a binding-post (klemme) *p*; from another binding-post *q*, extends a similar thin strip of metal as far as over the centre of the membrane, and carries a little platinum wire directed towards the membrane at right angles to the strip and the surface of the membrane. From binding-post *p* a conductor leads through a battery to a distant coil, which again is connected by another wire to binding-post *q*.

The coil at the distant station, is about six inches long, consists of about six layers of thin wire and encloses as a core a knitting needle which protrudes about two inches at each end. By these protruding ends the coil is supported on two bridges of a sound board. If now tones or combinations of tones are produced in the vicinity of the large opening of the conical cavity, so that sufficiently strong waves enter it, these waves will set the membrane into vibrations; by the outward motion of the membrane the platinum strip cemented on it is pressed against the hammer-shaped wire *d*, and the galvanic current (strom) is closed (geschlossen); by the inward motion of the membrane the current is reopened. The alternate magnetizings and demagnetizings of the core of the coil resulting therefrom

12090

will bring forth, if the alternation is slow the longitudinal tone of the core, and if the alternation (aufeinanderfolge) is quicker, a longitudinal vibration of the same, the period of which corresponds to the period of the interruptions of the current (unterbrechungen des stromes) or of the vibrations of the membrane, and consequently to the rate or pitch of the tone which entered the conical cavity. That means, according to the author, that "the rod (stab) reproduces the tone which was impressed upon the interrupting apparatus (unter prechungs apparat)." "The strength of this tone is also proportionate to the original tone, for," as the author, though not very accurately, exclaims, "the stronger this is, the greater the motion of the little hammer, the greater finally the time during which the circuit remains open, and consequently the greater, up to a certain limit, the motion of the atoms in the reproducing rod, which motions affect us as greater vibrations, as the original wave itself would have done." By means of this telephone the author made audible to the members of a large meeting of the Physical Society in Frankfort-a-M., melodies sung not very loud into the apparatus, in a house situated about three hundred feet distant with closed doors. "Other trials showed that the resounding rod is capable of reproducing full chords (dreiklange) of a piano on which the telephone rests, and that, in short, it reproduces just as well the tones of other instruments, such as the harmonica, clarinet, horn, organ-pipe, etc., provided the tones are within a certain range from F to f^2 or thereabout.

"As a matter of course, sufficient care was taken to ascertain whether direct transmission of the sounds had not a share in the result. This was ascertained very simply, by establishing for a given time a good shunt circuit directly before the coil, in consequence of which, of course, the activity of the latter ceased for that time.

"It was not possible thus far to reproduce spoken tones (tonsprache des menschen) with a distinctness satisfactory to all. The consonants are, for the most part, distinctly reproduced; the vowels not in the same degree." The author attempts to explain this imperfect reproduction of the vowels, by saying that the apparatus reproduces the vibrations to a certain extent indeed with proportionate, but also reduced strength, and the ear can no longer satisfactorily discern the relation of the proportionately great vibrations which determine the pitch (tonhohe) to the small vibrations on which vocal quality (vocal farbe) depends.

1191

(No. 19.) Defendants' Exhibit, Muller's-Pouillet's Description of Reis.

Lehrbuchdir Physik and Meterorologie. Von John Müller. Siebente Auflage, Zwieter Band, 1868, pp. 386–389

J. A. W., Sp. Ex'r.

[Introduced in Record, page 7.]

Galvanisches Tönen.

After describing the production of tones by passing an intermittent current through the coil of an electro-magnet, as practised by Wertheim and others, the author says :

When the breaks (Unterbrechungen) of the electric current follow each other in quick succession, the pitch of the magnetic tone we have just mentioned is indeed not changed thereby ; but there arises simultaneously another tone, which depends on the sum of the magnetic shocks (Stösse) which the iron atoms are subjected to, and has the same pitch as the tone offered by the breaking apparatus itself (Unterbrechungs apparat).

This tone, which arises by the side of the clicking noise, when the magnetic longitudinal tone of the rod is suppressed by the manner in which it is checked, is the one Reis made use of in the construction of his telephone.

Fig. 348 represents Reis' breaking apparatus (Unterbrechunges apparat). In the cover of the wooden hollow cube A a circular opening is made, which is closed by an elastic membrane (Schweinsdunndarm)—hog's intestine—stretched over it. On the middle of this membrane a little platinum plate is cemented, which, through a very thin metallic strip *f* (more conspicuous in Fig. 349), is connected in circuit with screw *a*. On the middle of the platinum strip a short platinum point rests, which is fastened at *g* on the under side of the piece of metal plate *h g i*, one end, *h*, of which rests upon little sup-

Fig. 348.

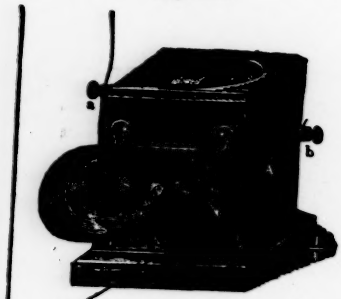


Fig. 349.

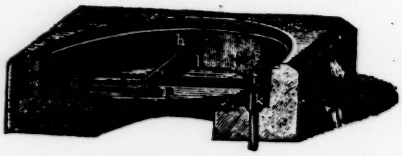
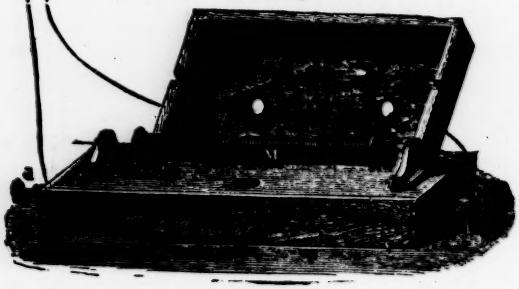


Fig. 350.



port *l*; whilst a platinum point fastened at *i* on its under side plunges in a hole of little metalic support *k*, said hole containing a small amount of quicksilver. Screw *b* is in electric connection with metalic support *k* (leitende Verbindung).

From one of the poles of the battery a conducting wire goes to screw *a* of the breaking apparatus (Underbrechunges apparat), Fig. 348; from the other pole of the same a wire goes to screw *d* of the

reproducing apparatus, to be mentioned next Fig. 350. Screw *c* of this apparatus is connected through a wire with *b* Fig. 348. Screws *c* and *d* are connected with the terminals of the small magnetizing coil M Fig. 350. By the connection just mentioned the current of the battery passes through the coil.

Now as soon as the sound waves of a sufficiently strong tone get into the mouthpiece of wooden cube A, the elastic membrane which closes the top opening of the same is thrown into vibration. Every entering wave of condensation raises the platinum strip as well as the little point resting thereon, but when the membrane oscillates inwards, the metalic plate *h g i*, with the little point fastened on at *i*, cannot follow quick enough. There occurs then for every vibration of the membrane a break of the current (unterbrechung des stromes), which shows itself in a spark occurring at the point of breaking (unterbrechungestelle). Through the coil M runs a knitting needle, which, as the figure shows, is fastened on a sounding board. A cover provided with a second sounding board can be turned over the coil, and in this way the tone can be much increased.

Now, if tones are produced before mouth piece *s* by singing into it or playing organ-pipes, one hears at the reproducing apparatus, placed as far as convenient at first, a peculiar crackling noise, which is independent of the pitch of the tones produced at the breaking apparatus, but, *besides these, tones themselves are distinctly and audibly reproduced by the steel wire ;* and Reis found this to be true indeed for all tones between F and *f*.

In the experiments of Reis the breaking apparatus was 300 feet distant from the coil ; in fact it was placed in another house with closed doors. But as the length of the conductors can be extended just as far as indirect telegraphy, Reis gave to his apparatus the name " telephone " (*Jahres Bericht des Physicalischen Vereigns Zu Frankfurt-a-M, Für 1860, 1861*).

2094

(No. 20.) Defendants' Exhibit, Bottger's Article.

Bottger's Polytechnisches Notizblatt, 1863, No. 6. On the Transmission of Tones at any desired Distance by means of Electricity. (Telephony).

J. A. W., Sp. Ex'r.

[Introduced in Record, page 7.]

Two decades ago the problem of giving signs, by means of electricity, from distances had not yet been entirely solved. Since then telegraphy has reached such a perfection and telegraph wires have so greatly spread that even the keenest desires have not much left to ask for.

Now there appears a first earnest trial to reproduce tones at any desired distance by means of electricity.

This first trial, which has been crowned with success, has been repeated in the lecture room of the Physical Society of Frankfort-on-the-Main, before numerous assembled members, on the 26th of October, 1861, by Mr. Ph. Reis, teacher of natural sciences at Friedrichsdorf, near Frankfort. Into one part of his apparatus, located in a building about three hundred feet distant, and having all the doors and windows closed, melodies were sung, but not very loudly. The same could be heard by the members in the lecture room through the second part of the apparatus.

These wonderful results were attained with the following very simple apparatus: a small, light box, a kind of hollow wooden cube, has a larger opening in the front and a smaller one on the opposite side. The latter is covered with a very fine membrane (sausage skin), and the same is tightly stretched; a small, flexible piece or strip of platina, fastened to the wood of the box, touches the membrane at its centre, and a second strip of platina is fastened by one end to the wood at a different place, and has at its other end a fine horizontal point touching the other strip of platina, where it lies on the membrane.

As is known, tones are produced by the rapid succession of condensations and rarefactions of the air. If the vibrations of the air, called waves, strike the thin membrane, they push the same against the strip of platina that touches it, and then allow it to immediately vibrate back into the hollow cube (called the artificial ear), and so cause the membrane to assume forms alternately bent towards the

2095

cube and from the same. The strip of platina lying against the membrane is thus set into a swinging motion, so that it is alternately pressed on to the platinum point of the second strip and then releaves the same.

If one of the strips is connected by a wire to one of the poles of a voltaic battery, and the electricity is conducted to any desired distance by a wire connected to the other pole and is then carried through a helix six inches in length, wound with six layers of thin silk-covered copper wire and from there is carried back to the second strip of platina on the wooden cube by means of an insulated wire, then, at every vibration of the membrane, an interruption of the current of electricity (Unterbrechungen der Stromungder Electricitat) will be caused, as the point on the one strip of platina no longer touches the other strip. Through the hollow of the spiral a thin iron wire (a thick knitting needle), about ten inches in length is passed, so that it projects out of each end of the spiral about two inches, and these projecting ends each rest on a bridge of a sounding board.

It is known that if an electric current is passed through a helix that surrounds an iron wire, at every interruption a tone produced by the vibrations of the iron wire, is audible. If the makings and breakings of the current (Unterbrechungen des Stromes) follow each other rather slowly, the different positions (in regard to the length of the bar), which the molecules will be caused to assume by the electricity will produce a tone, its so-called proper longitudinal tone which depends on the length and thickness of the bar or wire.

If the interruptions and re-connections of the current (Unterbrechungen des Electrischen Stromes) in the spiral take place faster than the vibrations of the smallest parts of the wire, which in turn depends upon the elasticity of the wire, they cannot complete their course, receive new shocks, the vibrations get to be smaller but more rapid, and as numerous as the interruptions follow each other. The piece of wire no longer gives its longitudinal tone, but a tone which, according to the number of interruptions in a certain time, is higher if they are more frequent and lower if they are less frequent. It is known that the pitch of a tone depends on the number of air waves that follow each other in one second. We have seen that the number of interruptions of the electric current (Unterbrechungen des electrishen Stromes) by the membrane and the strips of platina is dependent upon this.

Consequently the iron wire must give a tone of the same pitch

as the sound which was received by the membrane. As electricity is hardly impaired when conducted a great distance, if the proper apparatus is used, it is evident that a tone acting on a membrane in one place can be made audible at any desired distance by the iron wire.

That the tone is made audible only by electric vibrations, and not by direct transmission of the air waves through the wires can be most strikingly proved by noticing the fact that no tone is heard at the spiral if a good short circuit be established; *i.e.*, if, for instance, a small strip of metal is laid across the two wires, directly in front of the spiral, the reproduced tones are weaker than the originals, but the number of vibrations is the same. It is easy to reproduce the tones in the proper pitch as the vibrations are smaller which is the cause of the weakness of the tone, it is much more difficult, however, for our ear, to estimate the difference in the size of the vibrations.

The character of a tone depends upon the number of swellings it has, *i. e.*, with tones of the same depth, consequently of the same number of waves per second, such as having the fourth, sixth, eighth, tenth, or sixteenth waves stronger than the rest.

The physicists have shown that if a spring is vibrated by the teeth of a cog-wheel, the first vibration is the greatest, and every following one is smaller. If, however, before the spring comes to rest, another tooth strikes it, then the next vibration will be equal to the first strongest one, but the vibrations of the spring will not be any more numerous than before. Vowel tones can be artificially produced in this way.

Although we may be far from being able to converse with a friend a hundred miles away and recognize his voice, as though he was sitting along side of us, the impossibility of attaining this result can no more be claimed.

The probability that this result will be attained is almost as great as, by the wonderful experiments of Niepce, the reproduction of natural colors by photography.

(2097)

(No 21.) Defendants' Exhibit, Dr. Clemens' Publication. Clemens' Suggestions.

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 8.]

Deutsches Klinik, No. 48, Nov. 28, 1863, pp. 468–9.

This most wonderful phenomenon of the transmission of sound in the electrified wire I have observed once before, about ten years ago, in the following manner: A strong induction coil was set in motion with one cell of battery, and the current conducted above ground through a copper wire several hundred feet long from my study to a distant garden house. As soon as the wire thus extended was attached at the farther place to a strong coil, one could hear in that farther coil, quite distinctly, the running of the machine and likewise perceive at the second coil any tone which was able in any way to set up strong (bedentenden) vibrations. Shouting into a funnel, blows on a metallic plate, etc., if directed towards the induction coil, were heard distinctly in the farther coil like the tones of an Æolian harp. Herein lies more than a wonderful fact in keeping for the future.

(No. 22.) Defendants' Exhibit, Industrial Gazette.

"Deutsche Industrie Zeitung," 1863, Chemnitz. No. 9, April 17, 1863, No. 16, page 184:

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 8.]

"Industrial Queries for Exciting Interest and Eliciting Responses."

"Of late there has been talk in newspapers about producing definite tones at a distance, similarly to telegraphic dispatches, such for instance as conducting the acoustic effects of an instrument far beyond the reach of the audibility of its sound. Do these communications rest upon actual facts?"

No. 10, May 1st, 1863, No. 18, page 208.

"ANSWERS. Answer to question in No. 16, page 184. Transmission of tones by electricity. According to the 'Bottgers Notizblatt,' 1863, No. 6, 'Successful experiments in Telephony' were made in October, 1861, at Frankfort-a-M, by Prof. Ph. Reis, so that it seems not impossible to carry on conversations at miles distance, and even to convey the voice itself with its peculiar undulations, and also the tones of a musical instrument. Heretofore the voice could be reproduced from one house to another only for a distance of three hundred feet by means of a peculiar and ingenious apparatus. The arrangement of the same was essentially as follows: The waves of sound were taken up by an elastic surface and transmitted to a light commutator introduced into the circuit of a galvanic battery (einer federnden commutator eingeschaltet in den Leitungsdraht). At the other end of the lines introduced, a coil of copper wire, inside of which was an iron wire resting upon a sounding-board, that was thrown into sonorous vibrations by the changes of current depending upon the waves of sound."

No. 11, May 29, 1863, No. 22, page 249.

"*The reproduction of tones by electro-galvanic means (with a drawing, which is the same as the drawing of the apparatus in the Legat Article No. 8, pp. 539–45 Supra).*"

"Although this subject has already been discussed by us (No. 18,

page 208), on account of the great interest it offers, we shall return to it more in detail. We enclose a drawing of an apparatus used by Mr. Ph. Reis in Frankfort-a-M, taken from the Zeitschrift des Deutch-Oester eichschen Telegraphen Vereins, 1862, folios 6, 7 and 8. We take the liberty of following the lead of the above mentioned source in entering into a short discussion of the nature of tones.

"The undulations of the air that excite in us, by operating upon the ear, the sensation of sound, by setting the drum of the ear into vibration are transmitted, as is well known, by a series of levers of admirable delicacy, that is, by the small bones of the ear (hammer, anvil and stirrup), to the inner portion of the ear and to the nerves that lie at that point. The attempt to reproduce tones depends upon the following: To set in motion an artificial imitation of this series of levers by the vibration of a membrane which takes the place of the drum and to make use of them to open and close a galvanic circuit which is connected by a metallic conductor with a remote station.

"If we take into consideration the phenomena which takes place when we perceive a sound by the sense of hearing, we find that every tone is the result of rarefactions and condensations of the air repeated several times in a certain period. At every condensation the membrane of the drum is pressed inwards, and at every rarefaction outwards. These vibrations produce a simultaneous motion of the small bones of the ear, and a consequent transmission to the nerves of the ear. The greater the compression of the sound-conducting medium at any particular moment, the greater is also the amplitude of vibration of the membrane and small bones of the ear, and *vice versa*. The object, therefore, of the organs of hearing is to transmit with certainty the rarefactions and condensations of the sound-conducting medium to the nerves of hearing. On the other hand, it remains their object to bring to our perception the vibrations occurring in a given time with reference to number, as well as to amplitude. It is only in our perceptions that a given combination receives a definite name, that vibrations become sounds.

"Anything other than the effect of such single vibrations, the organs of hearing are unable to take up, and these organs themselves are competent to perceive single tones as well as combinations of tones, for if several tones are produced at the same time the sound-conducting medium is under the influence of several simultaneous forces, which, according to the laws of mechanics, can be

2100

replaced by a force which produces the same effect as all the single ones together. If all the forces operate in the same direction, the magnitude of the motion is proportional to the sum. If they operate in opposite directions, the magnitude of the motion is proportional to the difference of the opposite forces. In that way several simultaneous tones operate upon our hearing, simply by a definite alternation of rarefactions and condensations of the sound-conducting medium. As in the case of single tones, the tone itself depends apparently only upon the number of vibrations and the power upon the amplitude of the vibrations (perhaps also the strength).

"Now, as regards the apparatus, the upper figure is the transmitter and the lower one the receiver, or reproducer.

"The transmitter consists of a metallic conical pipe, *ab*, about fifteen centimetres in length, ten in diameter at *a* and four in diameter at *b*. At *b* the opening is closed by a membrane, *o*, of collodion, stretched tight. Upon the center of the same rests the end *c* of lever *cd*, whose fulcrum is placed at *e* on a support. The lever is to be made as light as possible, and its arm *c* longer than its arm *d*, so that the smallest motion at *c* will operate at *d* with the greatest amount of force. In the condition of rest the contact *dg* is closed, and a weak spring, *n*, holds the lever fast in this position of rest. Besides, there is attached to the apparatus a metallic standard, *f*, connected with one pole of the battery, while the other pole is led to the ground through *e*. On the standard *f* is secured the spring, *j*, opposite the contact point *d* of lever *cd* at *d*, the position of which (spring) can be regulated by a screw, *h*.

"The receiver consists of an electro-magnet, *m m*, resting upon a sounding-board, R, and whose coils are in connection with a metallic conductor, and with the earth at E. Opposite the electro-magnet is an armature, connected with the lever, as long as possible, but light and broad. This lever is fastened to the support *k* after the manner of a pendulum, and its motions are regulated by a screw, *b*, and a spring, *g*.

"To increase the efficiency of the apparatus, the receiver and reproducer can be set up in one focus of an elliptical concavity of proper size, while the listening ear of the hearer is placed in the other focus.

"The operation of the apparatus is now as follows: The tones of the voice or of an instrument are conducted into the conical pipe *ab*. By reason of their vibration the membrane is set into similar vibration, and in this way operates the opening and closing of the

electric conductor. In consequence of this the magnet in the receiver will be magnetized and demagnetized corresponding to the vibration of the tones, and the armature of the lever *i* is set in vibrations corresponding to those of membrane *o*. The wide surface of lever *i* transmits these vibrations to the air, and by this means they reach the ear of the hearer. In this transmission of tones, the only question is one of transmission of vibrations, a problem that magneto-electric telegraphy is certainly sufficiently far advanced to deal with.

"A friendly communication was sent us some time ago by Mr. J. F. Quilling, of Frankfort-a-M., according to which the capacity of the apparatus to transmit tones to a considerable distance clearly and with their characteristic timbre (Klangfarbe), is fully established. Mr. Q. writes us that by means of the telegraphic conductor with which the apparatus of Mr. Ph. Reis was connected, two remote parts of the city were united, and although it was not possible with the present construction of the apparatus to transmit spoken words (gesprochenen worte), they succeeded so well with the tones that were sung that not only were the melodies of songs reproduced distinctly and perfectly at a tolerably remote station, but known voices could be recognized.

"All present capable of judging, Mr. Q. adds, who availed themselves of the opportunity of witnessing the experiment, agreed that the possibility is before us of making oneself understood verbally at any distance in the way shown by Mr. Reis."

(No. 23.) Defendants' Exhibit, Gartenlaube Reis Improved Apparatus.

(*The "Gartenlaube," No. 51, December, 1863.*)

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 8.]

THE MUSICAL TELEGRAPH.

The surprising results in telegraphing have often excited the question whether it may not be possible to communicate the language of sound itself to a distance. The trials made in this direction had till now produced no satisfactory results, because the vibrations of sound-conducting bodies soon diminish so much in force that they are no more perceptible for our senses.

People, perhaps, had already thought of a reproduction of sound at certain distances with the aid of the electric current, but those who have been the best fitted to attack the question, by their knowledge and resources, were the ones who doubted the most of a practical solution of that question. Those who are but superficially acquainted with natural science do not see the many difficulties this problem offers, if they are at all acquainted with it. Thus, about eleven years ago, a young man, Mr. Philip Reis, at present teacher of natural sciences at the Garnier Institute for Boys at Friedrichsdorf, near Homburg, had the hardihood to work at the solution of this problem. But soon he was obliged to desist from it because his very first effort seemed to convince him of the impossibility of a solution. Later, however, after further studies and many experiments, he saw that his first effort was but a rudimentary one, and by no means convincing. However, he did not recommence to attack the question seriously for some time, not feeling himself strong enough to vanquish the obstacles on his road, although he never banished his early idea entirely from his thoughts.

How can a single instrument reproduce simultaneously "the combined effects of all the organs active in human speech?" This seemed to him the chief question. Later he put his question more methodically: "How does our ear perceive the composite vibrations of all the organs of speech acting at the same time?" or, expressed more generally, "How do we perceive the vibrations of several bodies sounding simultaneously?" If we throw a stone into quiet water there are produced on the surface uniform waves which progress symmetrically outward; the further they go the weaker they become, till they finally disappear.

It is quite similar with that what we call sound and tone. A body made to vibrate through any impulse affects the surrounding air, and causes waves in it, which follow each other at the same rate as the vibrations of the body. As those rings on the water consist in swellings and depressions, so also the vibrations of the air consist of alternate condensations and rarefactions. If they reach our ear every condensation presses the tympanum towards the interior of the cavity, and puts in motion the adjacent group of small bones which communicates the motion to the liquid of the cochlea, in which the auditory nerves terminate. The latter are excited and produce the *sensation of sound.*

Now, if the waves of vibration follow regularly and with a certain swiftness (sixteen in the second at least), we shall have the sensation of a musical *tone.* The latter is the *higher* the quicker the condensations follow each other, and the louder the *stronger* or higher the waves rise, as it were.

Our ear cannot perceive anything except condensations and rarefactions, wave crests and wave hollows. And, nevertheless, we receive the most varied auditory impressions, we distinguish the sound of the voices, we hear at the same time in quite different directions and can distinguish the different sources—nay, in a complete large orchestra, each of the numerous instruments is specially noticed by its peculiar sound, so that we decompose at every moment the total impressions into its several parts, according to the height and depth, strength and weakness, or according to the timbre (or quality) Klangfarbel.

Referring to our simile, this is about the same as if we throw two or more stones at different places into a calm pond. The wave lines cross each other, strengthen each other at some points, weaken each other at others, and the surface has a ruffled, hillocked aspect. But, nevertheless, our eye can detect the different systems of rings and can trace them back to their several causes. If we succeed in transmitting with the galvanic current the oscillations of a sounding body to a distance, so that there another body is put to equally rapid and, in respect to each other, equally strong oscillations, the problem of "telephoning" is solved.

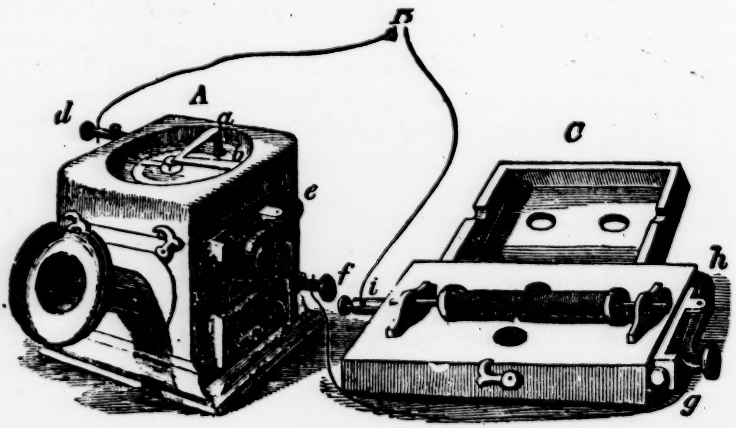
For then exactly the same phenomena of waves are called forth on the distant points as the ear receives at the place of origin; therefore they also must make the same impression. The ear will distinguish at the distant points not only the single tones, according to their varying height and depth, but also to the proportionate force of the vibrations, and not only single melodies, but the per-

2104

formance of a whole orchestra ; yes, even speech must be heard at the same time, in places very distant from each other. Mr. Reis was the first one to prove by experiments the possibility of solving this problem. He has succeeded in constructing an apparatus to which he gives the name *Telephone*, and which enables one to reproduce tones, with the aid of electricity, at any given distance. Already, in October, 1861, he made rather successful experiments with a very simple, rudely-made apparatus, before a numerous audience at Frankfort. On July 4th of the present year, he presented an essentially improved apparatus at an assembly of the "Physical Union," which transmitted, by closed doors and windows, a melody sung moderately loud, to a distance of about three hundred feet, so that it could *be heard plainly.*

In order to give an opportunity to larger circles, especially to scientific men, to convince themselves of the efficiency of this essentially improved apparatus, Prof. Bottger, of Frankfort-a-M., made lately (at an assembly of German physicists and doctors in Stettin, in the sectional meetings for natural sciences) several experiments which certainly would have been crowned with still more success if the hall in which the session was held had been located in a less noisy part of the city and filled with a less numerous audience.

Although, for the present, we are not so far along as to be able to converse with a friend at a distance of several hundred miles, so much at least is certain, that with the aid of the telephone, songs of all kinds, melodies, especially in the middle registers, can be reproduced most clearly at unlimited distances. These wonderful results are obtained with the following simple apparatus, which we show here in one-fourth of its size :



A small box, A (the telephone proper), a kind of hollow cube has a mouthpiece, S, on the front side, and a somewhat smaller opening on the upper side of the box. The latter is closed with a fine membrane (skin from the intestines of a hog), tightly stretched. A narrow strip of platina, *m*, connected with the screw post, *d*, touches directly the membrane on its centre; a slender platina point, *k*, attached to the angle, *a b*, touches the strip of platina which rests on the membrane. If one sings into the mouthpiece, S (by filling the same entirely with the mouth), the thin membrane vibrates and the attached platina strip receives likewise a vibrating motion, so that it is alternately pressed against and leaves the platina point, *k*.

From the binding post, *d*, which communicates with the platina strip resting on the membrane, a conducting wire is connected with one of the poles of a galvanic battery, B (about three to four six-inch Bunsen elements), and then the electricity is led through a wire attached to the second pole of the battery to the distant station, C; there, at *i*, it passes through a coil, *l l*, formed of copper wire covered with silk thread, then back again to screw *f*, and there to the platina point, *k*. At every vibration of the membrane an interruption of the electric current (unterbrechung des electrischen Stromes) takes place by the platina point parting from the platina strip.

Within the wire coil at station, C, is a thin iron wire (a strong knitting needle), which is about ten inches long, and which, with its two ends projecting out of the coil for about two inches, each rests on two bridges of a sounding box. This is the *reproducing* apparatus.

At every interruption of the current (Unterbrechung des Stromes) in the coil the iron rod is made to vibrate. If the motions follow with a certain rapidity, they produce a tone which is rendered audible by the sounding box. As the rate of the interruptions depends on the pitch of the tone that has been sung into the mouthpiece, the same tone is sounded with the same pitch from the sounding box. The length of the circuit has no influence upon this. It is true the electric current loses force the farther it goes, but there is no reason why relays should not be employed, the same as in telegraphing, and with their aid any number of reproducing apparatuses be set into simultaneous vibrations. Mr. Reis has endeavored to give to his improved apparatus a form which should also be pleasing to the eye, so that it might fill worthily its place in any physical laboratory. He has applied, moreover, to the side of

2106

the telephone, as well as to the reproducing apparatus, a small telegraph arrangement, which is a very good addition for convenient experimenting. (It is indicated in the drawing by the letters *e f h g*.) By alternately opening and closing the circuit with the key, *e* or *h*, the most varied signals may be given after mutual agreement; for instance, if one is ready for singing; if everything has been understood, whether one should stop singing or commence anew, etc.

Mr. Reis himself manufactures the principal parts of the telephone, for which no small amount of physical knowledge and experience is necessary. The mechanician, Wilhelm Albert, at Frankfort, is charged with manufacturing the less important parts and the external outfit, as well as with the sale of the instrument at a low price.

(No. 24.) Defendants' Exhibit, Polytechnisches Centralblatt, 1863, pp. 857–9.

This is a reprint of Bottger's article, No. 20, *supra*.

J. A. W., Sp. Ex'r.

[Introduced in Record, page 8.]

2108

(No. 25.) Defendants' Exhibit, Reis's Letter to Ladd.

Journal of the Society of Telegraph Engineers and of Electricians, for March, 1883, No. 46.

J. A. W., Sp. Ex'r.

[Introduced in Record, page 8.]

Reis's Telephone.

The following is a copy of an autograph description of Reis's telephone, which has been presented to the library by Mr. Wm. Ladd, member:

(Copy.)

Institut Garnier,
Friedrichsdorf.

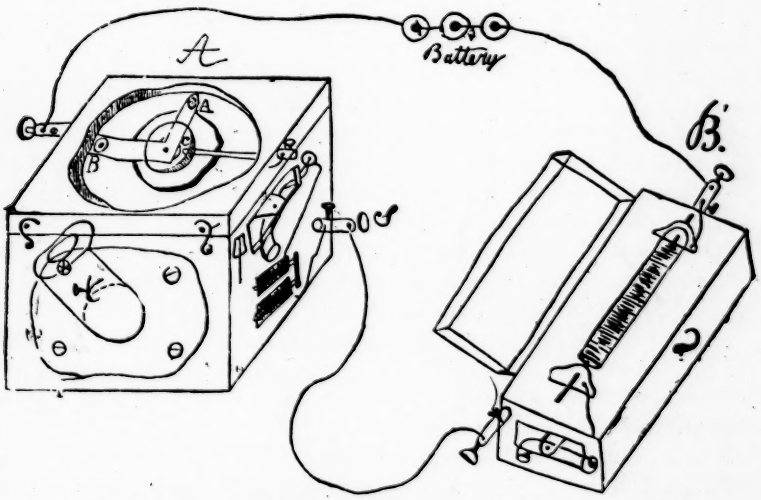
Dear Sir—I am very sorry not to have been in Frankfort when you were there at Mr. Albert's, by whom I have been informed that you have purchased one of my newly-invented instruments (telephone), though I will do all in my power to give you the most ample explanations on the subject. I am sure that personal communications would have been preferable, specially as I was told that you will show the apparatus at your next scientifical meeting, and thus introduce the apparatus in your country.

Tunes and sounds of any kind are only brought to our conception by the condensations and rarefactions of air or any other medium in which we may find ourselves. By every condensation the tympanum of our ear is pressed inwards, by every rarefaction it is pressed outward, and thus the tympanum performs oscillations like a pendulum. The smaller or greater number of the oscillations made in a second given us, by help of the small bones in our ear and the auditory nerve, the idea of a higher or lower tune.

It was no hard labor, either to imagine that any other membrane besides that of our ear could be brought to make similar oscillations, if spanned in a proper manner, and if taken in good proportions, or to make use of these oscillations for the interruption of a galvanic current. However, these were the principles which guided me in my invention; they were sufficient to induce me to try the reproduction of tunes at any distance. It would be long to relate all the fruitless attempts I made, until I found out the proportions of the instrument and the necessary tension of the membrane. The

apparatus you have bought is now what may be found most simple, and works without failing when arranged carefully in the following manner:

The apparatus consists of two separated parts, one for the singing station A, and the other for the hearing station B.



Reis's Telephonic Apparatus—Fac-simile of Drawing sent by Reis to Mr. Ladd.

The apparatus A is a square box of wood, the cover of which shows the membrane *c*, on the outside, under glass. In the middle of the latter is fixed a small platina plate to which a flattened copper wire is soldered, on purpose to conduct the galvanic current. Within the circle you will further remark two screws; one of them is terminated by a little pit in which you put a little drop of quicksilver; the other is pointed. The angle which you will find lying on the membrane is to be placed according to the letters, with the little hole *a* on the point *a*, the little platina foot *b* into the quicksilver screw, the other platina foot will then come on the platina plate in the middle of the membrane.

The galvanic current coming from the battery (which I compose generally of three or four good elements) is introduced at the conducting screw near *b*, wherefrom it proceeds to the quicksilver, the movable angle, the platina plate and the complementary telegraph to the conducting screw *s*. From here it goes through the conductor to the other station B, and from there returns to the battery.

2110

The apparatus B, a sonorous box, on the cover of which is fixed the wire spiral with the steel axis, which will be magnetic when the current goes through the spiral. A second little box is fixed on the first one, and laid down on the steel axis to increase the intensity of the reproduced sounds. On the small side of the lower box you will find the corresponding part of the complementary telegraph.

If a person sing at the station A in the tube *x*, the vibrations of air will pass into the box and move the membrane above, thereby the platina foot *c* of the movable angle will be lifted up, and thus will open the stream at every condensation of air in the box. The stream will be re-established at every rarefaction. In this manner the steel axis at station B will be magnetic once for every full vibration, and, as magnetism never enters nor leaves a metal without disturbing the equilibrium of the atoms, the steel axis at Station B must repeat the vibrations at station A, and then reproduce the sounds which caused them. *Any* sound will be reproduced if strong enough to set the membrane in motion.

The little telegraph which you find on the side of the apparatus is very useful and agreeable for to give signals between both of the correspondents. At every opening of the stream, and next following shutting, the station A will hear a little clap, produced by the attraction of the steel spring. Another little clap will be heard at station B in the wire spiral. By multiplying the claps, and producing them in different measures, you will be able as well as I am to get understood by your correspondent.

I am to end, sir, and I hope that what I said will be sufficient to have a first try; afterwards you will get on quite alone. I am, sir,

Your most obedient servant,

PH. REIS.

FRIEDRICHSDORF, 13–7–63.

To Mr. WILLIAM LADD.

2111

(No. 26.) Defendants' Exhibit, "Tagesblatt der 39 Versamlung Deutsche Naturforscher," Giessen, September, 1884: From Prof. Sylvanus F. Thompson's Book on Philipp Reis, p. 94.

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 8.]

EXTRACT FROM THE REPORT OF THE GERMAN NATURALISTS' SOCIETY, HELD AT GIESSEN (1864).

"Afternoon sitting on 21st September, 1864.

"Prof. Buff speaks about the tones of iron and steel rods when magnetized, and exhibits the corresponding experiments.

"Dr. Reis demonstrates his telephone, gives thereupon an explanation and the history of this instrument.

"Prof. Poggendorff produces tones in a metal cylinder, the slit up edges of which touch one another firmly, and which is placed loosely round an induction-bobbin, through which there goes an interrupted current."

Defendants' Exhibit No. 27.

[See Defendants' Exhibit No. 74, introduced p. 76, Defendants' Case.]

2110

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Defendants' Exhibit No. 27.

[See Defendants' Exhibit No. 74, introduced p. 76, Defendants' Case.]

(No. 28.) Defendants' Exhibit, Kuhn's description of Reis.

Handbuch der Angewandten Elekricitatsslehre von Karl Kuhn, 1865, pp. 1017–1021.

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 8.]

The experiments made by Reis in Frankfort-a-M., on the 26th October, 1861, have proved, however, that when the breaks of the current (stromunterbrechungen) follow each other almost continuously and very quickly in a coil provided with a thin iron core, the iron wire can enter into longitudinal vibrations, and in this way be enabled to reproduce sounds of different pitch. An exact reproduction of the sounds does not take place, however, but only an imitation; for this reason it cannot be questioned here of transverse vibrations (transversal schwingungen). A phenomenon (erscheinung) has otherwise been heard of, which belongs to the aforementioned class, in which the intensity and the timbre (klang) of the sound accompanying it (the phenomenon) depend among other things on the strength of the current (strom starke) and on the number of breaks of the same, and in which, as it seems, the pitch of the tones also can vary under different circumstances. We can, however, hardly imagine by what arrangements it would be feasible to coax tones of any given height or depth out of an iron or metal tube split on one side, while it (the tube) is affected by the alternate currents of an induction apparatus the coil (rolle) of which surrounds it. Yet the possibility cannot be controverted that the principle of Neef's circuit breaker (unterbrecher) might contribute to the solution of the problem in question. It has been employed

for local purposes either with or without modifications in the study and investigation of acoustic phenomena. Thus Petrina has used the principle of Neef's circuit breaker (unterbrecher) for his electric harmonica in this way, that instead of the Neef hammer a little rod was chosen, the transverse vibrations of which rendered the tone "there are four little rods of various length, side by side, the motions which are checked by means of levers managed by finger keys." That principle was used previously by Dove in a modified manner, to set strained strings and elastic springs into acoustic vibrations of constant amplitude by means of an electric magnet, and, in this way, to be enabled to investigate constant tones. It appears from Legat's published communications that "the ideas submitted by Ph. Reis of Friedrichsdorf in the Physical Society and in the meetings of the German Hochstift in Frankfort-a-M., about the reproduction of sounds by means of electricity," referred to arrangements of a similar kind. Legat mentions in his paper all that has been done thus far towards the realization of that project, and we borrow from it that part only which throws some light on the construction of a telegraphic apparatus with which it is said to be possible to produce vibrations and make sounds in any desired manner and through which the employment of electricity is said to make it feasible to bring forth at any given distance vibrations similar to the first produced ones, and in this way to reproduce at a certain place tones originally produced at another place.

This apparatus is composed of a transmitter and of a receiver. The transmitter (Fig. 504, p. 1016) consists in a conical tube *a b*, about 15 cm. long, 10 cm. at the front, 4 cm. at the back opening; the choice of the material, as well as a greater length, is indifferent; a greater width, on the contrary, is disadvantageous; the surface of the interior must be as smooth as possible. The narrower back opening is closed by a membrane of colodion, *o*, and on the middle of the circular surface formed by this membrane rests one end, *c*, of lever *c d*, the fulcrum of which is held by a support and remains connected with the metallic circuit. This lever, one arm, *c e*, of which must be considerably longer than *e d*, should be as light as possible so as to follow easily the motions of the membrane, as an

3114

Fig. 50a.

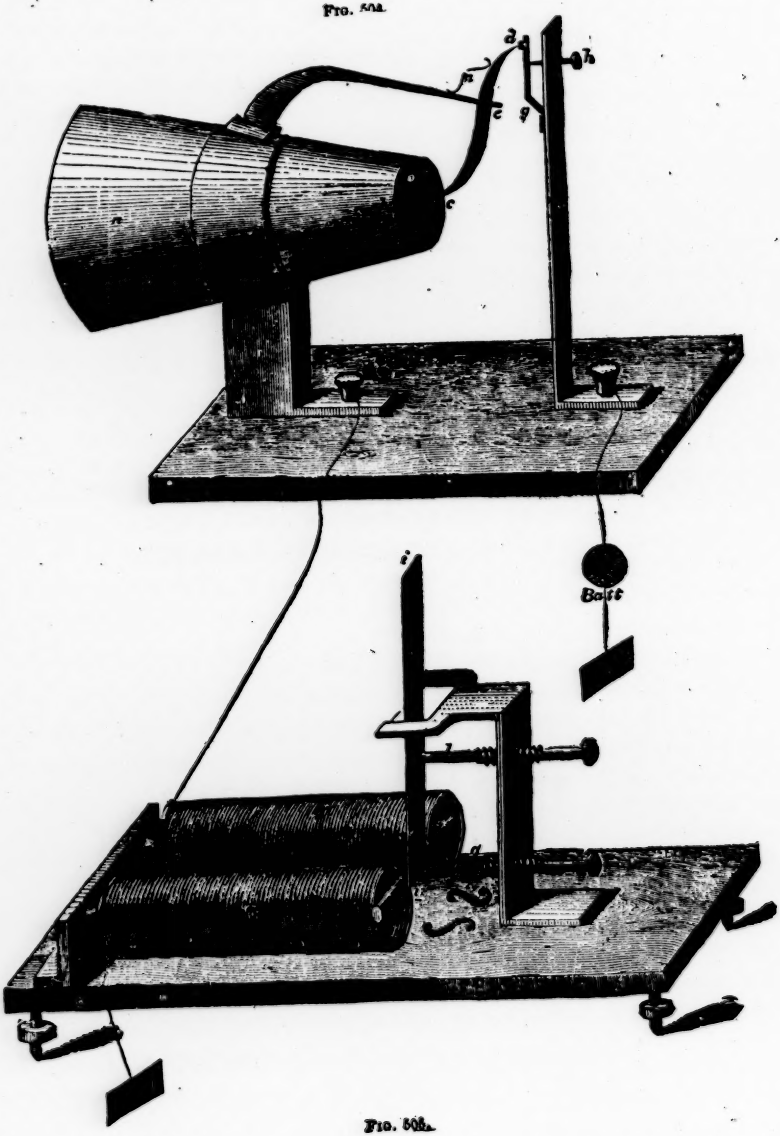
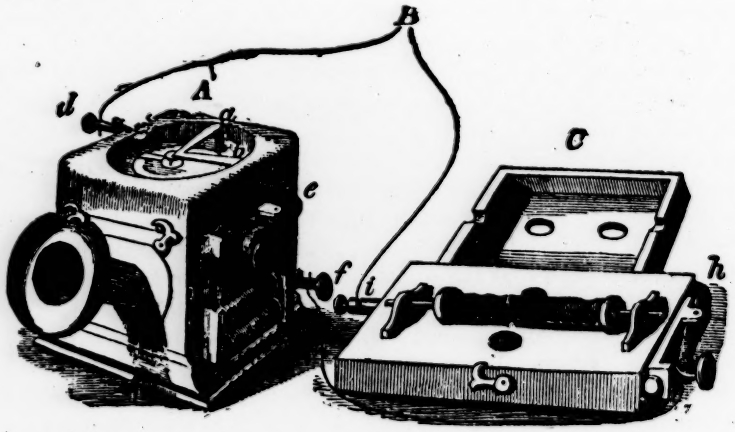


Fig. 50b.

uncertain obedience (folgen) on part of lever *c d* would produce imperfect tones at the receiving station. In the state of rest the contact *d g* is shut and a weak spring *n* holds the lever fast at rest. On the metallic support *f*, which is connected with one of the poles of the battery, is a spring *g* with a contact which touches the contact of lever *c d* at *d* and the position of which is regulated by screw *h*; over tube *a b* a disk must be placed which encircles the outer circumference of the tube closely, so that the efficacy of the apparatus may not be impaired through the effect of the air waves coming round and striking against the rear end. This disk at right angles with longitudinal axis of the tube measures about 50 (?) cm. in diameter. The receiver (Fig. 505) consists of an electro-magnet *m m*, which rests on a sounding board and the coil of which is in connection with the metallic conductors and with the ground. Opposite the electro-magnet is an armature connected with a lever as long as possible, but light and broad, which latter with the armature is fastened pendulum like on the support *k*. Its motions are regulated through screw *l* or spring *o*. "In order to increase the efficacy of the apparatus, this receiver can be placed in one focus of an elipsoidal enclosing box of suitable size, while the ear of the hearer is placed at the other focus." The working of the two apparatus (the mode of connection of which is visible in woodcuts), the transmitter being placed at one station and the receiver at the other, is as follows: By speaking, singing, or the intromission of instrumental sounds into tube *a b*, in consequence of the condensation and rarefaction of the column of air, a motion of the membrane *c* corresponding to these changes is brought about. Lever *c d* follows the motion of the membrane, and opens or closes the circuit according as a condensation or a rarefaction of the air inside takes place. As a consequence the electro-magnet *m m* (Fig. 505) is correspondingly demagnetized or magnetized, and the armature affixed to it (as well as the armature lever) is set into similar vibrations as the membrane of the transmitter. Through lever *i*, connected with the armature, similar vibrations are communicated to the surrounding air and (the increasing effect of the sounding board helping) the tones so produced finally reach the ear of the listener. In respect to the operations of this apparatus, the author remarks that the receiver does reproduce the exact number of the original vibrations, but that a reproduction of the original intensity has not yet been attained. For that reason, it is added, small differences in the vibrations are appreciated with difficulty, and in the practical ex-

2116

periments made thus far it was possible to transmit with astonishing faithfulness chords, airs, etc., whilst in reading, speaking, etc., single words were more indistinctly heard. The apparatus just described is said to have been one of the constructions which Reis has used himself in his experiments. The underlying principles might give hopes of a further improvement of the apparatus, but the telephone which, according to later reports, Reis has finally decided upon has the disposition represented in Fig. 506, although the principle on which it is founded does not stand quite in harmony with the above-mentioned investigations of Wertheim, for instance.



The telephone proper A, consists of a hollow wooden box provided with a short sound funnel S, and the upper side of which is open in the centre and covered over tightly with a delicate membrane. On the middle of the latter a thin platinum disk is fastened from which on one side a platinum strip establishes circuit connection with the contact of the key at *e*, from which place the metallic connection is effected with one end of the coil of a small electromagnet provided with a spring armature, whilst the other end is in contact with screw *f*. The reproducing apparatus C, set up at the receiving station, consists simply of a coil about six inches long formed by winding six layers of copper wire; in the axis of the coil a thin iron wire ten inches long (a knitting needle) protruding out of each end of the coil about two inches, is so disposed that with its bridge-like supports it rests on a sounding board. By means of screw *i*, and of the key at *h g*, the coil is thrown into the circuit and

the connection of both apparatus is effected in the manner mentioned; a battery being placed at B, the course of the current is easily followed out. It can flow from B through *d c* and *c b* to *e* and *f*, and from here to the receiving station, and at *i* return to the battery, or it can start in the opposite direction according as *d* or *i* forms the starting point of the current. The circuit can be broken at will at each of the two stations by pressing the key lever, and a connection can be established thus in either direction, but the discontinuous currents which are to produce the sounding of the iron wire at C are obtained in this way. By singing or the blowing of instruments towards the sound funnel S, the membrane at A is made to vibrate; if this can be brought about it will happen, as was demonstrated by the experiments, that the iron wire of the receiver assumes isochronal vibrations, and whenever this is the case, it reproduces the same tones which set the membrane to vibrating at the transmitting station.

My own experiments have demonstrated that every melody starting from *c*, and embracing the entire extent of an average male voice, when sung into the telephone, can be reproduced by the receiver at C. The timbre (Klang) or quality of the sounds thus reproduced is not pleasant, they are almost like the sounds of toy trumpets, at times also like the buzz of a fly caught in a spider's web and the like; yet the experiments of Reis are certainly interesting enough to challenge attention.

A reproduction of the words spoken into the telephone with or without variation of pitch was audible at the receiver only in a corresponding noise (entsprechendes Gerausch), while a discriminate perception of single vocal sounds, syllables or words could not be had. According to communications made on this subject by Reis, he has succeeded in reproducing the tones of organ pipes not covered, and those of a piano; in this latter case the transmitter was placed on the sounding board of the piano.

February 20, 1885.

2118

(No. 29.) Defendants' Exhibit, Albert's Catalogue of 1873.

Catalogue of J. Wilh. Albert, Mechanician, at Frankfort-on-the-Main, 1873.

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 9.]

(Extract from Preface). All instrument and apparatus will always be constructed according to the latest designs and improvements. In order that their construction may be better understood we have printed herein references where a more complete description can be found, as follows:

M.-P. Muller-Pouillet's Lehrbuch der Physik, VII. Auflage.

A list of other books is given.

In the body of the catalogue is the following:

957. Telephone of Reis for reproduction of tones by electricity, with description, 21 florins, 36 Rm.

(M.-P. Fig. 348, bis. 350, Pisco, Akustik, fig. 60.)

958. The same, with a simple electro-magnetic signalling apparatus, 26 fl., 15 kr., 45 Rm.

2119

(No. 30.) Defendants' Exhibit, "Zeitschrift Deutsch-Oesterriskischen Telegraphen Veriens." Berlin, Prussia. 1862. Vol. 9, p. 125.

(Contains reprint of the "Reis-Legat Article." See No. 6.)

J. A. W., Sp. Ex'r.

(No. 32.) Defendants' Exhibit, Journal of the Society of Architects and Engineers for the Kingdom of Hanover, Vol. XII., page 147, A. D. 1866.

J. A. Welch, Special Examiner, May 13, 1884.

[Introduced in Record, p. 9.]

New System of Acoustic Telegraphy.

The Dublin Medical Press publishes an article upon the new apparatus which permits the sound of the human voice to be transported to remote places. A person speaks into a tube near which a membrane is stretched, the vibrations will be carried through the conducting wire to a similar membrane at the receiving station ("endstation"). By means of the same vibrations the same sounds will be produced, and so shall it be possible, in fact, to carry on a conversation with another part of the world. Compare this report with Dinglar's, Part 4, 1864.

(33.) Defendants' Exhibit, The Dublin Medical "Press" Wednesday, Oct. 14th, 1863. Vol. L., No. 1293, p. 471.

J. A. Welch, Special Examiner, May 13, 1884.

[Introduced in Record, p. 9.]

An extraordinary invention has been planned and perfected—namely, telegraphing by voice to vast distances, say, between London and Liverpool. The operator places his mouth to the tube in front of the instrument and sings a note, when immediately the membrane begins vibrating in accordance with the note sounded, and causes the iron core in the receiving instrument at the other end to be magnetized and demagnetized a number of times equal to the number of vibrations of the membrane, and so conveys to the receiver an impression of a musical sound the same as transmitted at the other end. This, it is hoped, will extend from vocal tones to verbal tones.

(No. 34.) Defendants' Exhibit, Cosmos (Moigno).

Weekly Encyclopedic Review of the Progress of the Sciences. Paris, December 25th, 1863. Vol. 23, p. 705.

J. A. Welch, Special Examiner, May 13, 1884.

[Introduced in Record, page 9.]

Acoustic Telegraphy.—There has been invented and constructed in England an electric telegraph apparatus which permits the notes of the human voice to be transmitted from one point to another very distant one. The operator places himself before the instrument and sings into the tube any note whatever. A membrane stretched near to the tube, so as to vibrate under the influence of the note sung, is put in connection by a wire conductor with another membrane placed in the same conditions at the station to which one speaks.

The number of the vibrations of the first membrane corresponds exactly to the opening or the interruption of the electric current transmitted by the wire conductor to the opposite membrane, this one, under the influence of the currents, vibrates in unison with the first and renders also a sound identical with the sound sung. There is but one more step to make, adds the Dublin "Medical Press," and one will be able to speak, in the proper sense of the word, from one end of the earth to the other.—Notes of M. Koenig.

(No. 35.) Defendants' Exhibit, "Scientific American Supplement," February 5, 1876. Pp. 92-93.

J. A. W., Sp. Ex'r.

[Introduced in Record, page 9.]

ON THE TRANSMISSION OF MUSICAL TONES TELEGRAPHICALLY.

By Elisha Gray.

(Read before the American Electrical Society, March 17th, 1875.)

While engaged in studying the phenomena of induced currents, I had noticed a sound proceeding from an electro-magnet connected in the secondary circuit of a small Ruhmkorff coil which was at that time in operation. This, of course, was not new (in having been observed by Page, Henry, and others, that the magnetization of iron is accompanied with sound), but it helped to direct my mind to the subject of transmitting musical tones telegraphically. Subsequently, I made a discovery that led to a thorough investigation of the subject, and I have devoted my whole time since then to the study which it suggested.

The circumstance was as follows: My nephew was playing with a small induction coil, and, as he expressed it, was "taking shocks" for the amusement of the smaller children. He had connected one end of the secondary coil to the zinc lining of the bath tub, which was dry at that time. Holding the other end of the coil in his left hand, he touched the lining of the tub with the right. In making contact, his hand would glide along the side for a short distance. At these times I noticed a sound proceeding from under his hand at the point of contact, which seemed to have the same pitch and quality as that of the vibrating electrotome, which was within hearing. I immediately took the electrode in my hand, and, repeating the operation, to my astonishment found that by rubbing hard and rapidly I could make a much louder sound than the electrotome was making. I then changed the pitch of the vibration, increasing its rapidity, and found that the pitch of the sound under my hand was also changed, it still agreeing with that of the vibration. I then moistened my hand and continued the rubbing, but no sound was produced so long as my hand remained wet; but as soon as the parts in contact became dry the sound reappeared.

The next step was to construct a key-board, with a range at first

of one octave, similar in appearance to the cut shown in Fig. 1, which has two octaves.

Each key has a steel reed, or electrotome, tuned to correspond to its position in the musical scale. A better understanding of the operation of a key and its corresponding electrotome may be obtained by referring to the detached section shown in Fig. 1 *a*.

a is a steel reed tuned to vibrate at a definite rate corresponding to its position in the scale. One end is rigidly fixed to the post *b*, while the other end is left free, and is actuated by a local battery. The magnets *e* and *f* are arranged in the same local circuit, magnet *f* having a resistance of about thirty ohms, and magnet *e* about four ohms. When the read *a* is not in vibration the point C is in electrical contact with it, which throws a shunt wire entirely around the magnet *f;* thus, practically, the whole of the local current passes through magnet *e* at the instant of closing the key C. It is well known that when two electro-magnets are placed in the same circuit, the one which has the higher resistance (other things being equal) will develop the stronger magnetism, and that if the magnet of higher resistance be taken out of the circuit, the force of the other will be increased. When the key C, being depressed, closes the local circuit at *d*, the operation of the reed is as follows: The whole of the current from battery L passes through the magnet *e*, which attracts the reed, say, with a power of four. When the reed has moved towards I far enough to leave the point G, the shunt circuit is broken, and the current flows through both the magnets immediately the power in *f* rises from zero to five, and that of *e* drops from four to one, and the reed is attracted toward *f* with an effective force of four, until contact is again established with the point G. The operation is repeated at a rate determined by the size and length of the reed, and which corresponds with the fundamental of the note its represents. The figures given above only approximate the facts. The relation of the magnet as to size and resistance, so as to give an equal impulse to the reed in both directions, was determined by actual experiment with a battery of a given size.

It will be observed that by this arrangement the centre of vibration coincides with the centre of the reed when at rest, so that the pitch of the tone is not disturbed by any ordinary change of battery, as is liable to be the case when only one magnet is used, or when the impulse is not equal in both directions.

A second battery, which we will call the main battery, is connected as follows: One pole is connected to the ground; the other runs to

the instrument, and, entering at binding screw 4 (Fig. 1 *a*), runs to point H of key C to point *i*, which makes contact with the reed *a;* from the reed *a* to binding screw *l*, and thence to line. It will be seen that when the key is at rest the batteries are open at the points *d* and H.

All the keys in the instrument, whether one or more octaves, have corresponding reeds and actuating magnets, the only difference being in the tuning of the reeds. There is but one main and one local battery used, and the connections to each key are run in branch circuits from the binding screws, as shown in Fig. 1 *a*. But since all these branches are open at the key points, neither of the batteries is closed unless a key is depressed.

If now the keys are manipulated, a tune may be played which is audible to the player. When any key is depressed, the local battery sets in vibration its corresponding reed, which sounds its own fundamental note according to the laws of acoustics. So far the instrument is an electrical organ, the motive power being electricity instead of air. The main battery has had no part whatever in its operation.

If, however, the main circuit is closed by connecting the distant end to ground, and the point I is properly adjusted so that it makes and breaks contact with the reed at each vibration, a series of electrical impulses, or waves, will be sent through the line, corresponding in number per second to the fundamental of the reed.

Now as the pitch of any musical tone is determined by the number of vibrations per second made by the substance from which the sound proceeds, it is clear that if these electrical waves can be converted into audible vibrations at the distant end of the line, whether it be one mile or five hundred miles from the player, the note produced will be of the same pitch as that of the sending reed.

There are various ways by which these electrical waves may be converted into audible material vibrations. One of the most curious and novel is the one in which animal tissue plays a prominent part. Following out the idea suggested by the bath-tub experiment, I constructed various devices with metallic plates for receiving the tune by rubbing with the hand. A very convenient method for doing this is shown in Fig. 2.

This instrument has a metal stand of sufficient weight to keep it in position while being manipulated. Upon the stand a horizontal shaft is mounted in bearings, upon one end of which is a crank, with a handle made of some insulating substance. Upon the other end is

centered a thin cylindrical sounding-box, made of wood, the face of which is covered with a cap made of thin metal, spun into a convex form to give it firmness. This box has an opening in the centre to increase its sonorous qualities. The metal cap is electrically connected to the metal stand by means of a wire.

If the operator connects the cap, through the stand, to the ground, and taking hold of the end of the line with one hand, presses the fingers against the cap, which he revolves by means of the crank with the other hand, the tune that is being played at the other end of the line becomes distinctly audible, and may be heard throughout a large audience room. If the conditions are all perfect, the faster the plate is revolved the louder will be the music, and the slower the the motion the softer will it become. When the motion stops the sound entirely ceases.

I have found that electricity of considerable tension is needed to produce satisfactory results, at least that of fifty cells of battery. The necessary degree of tension is most conveniently obtained by passing the line current through the primary circuit (adapted to the circuit wherein it is used) of an induction coil, and connecting the receiver in the secondary circuit.

The cause of this phenomena has been the source of much speculation and experiment. At first, I supposed it to be the quivering of the muscles at the hand, produced by the electric impulses and communicated to the plate and box making an audible sound, and that the motion was produced through the medium of the nerves. This idea, however, had to be abandoned. While visiting in England, in 1874, I called on Professor Tyndall at the Royal Institution, and exhibited to him a portion of my apparatus. He experimented with various substances, and found that the same result in kind if not in degree, could be produced with dead animal tissue. For instance, a bacon rind that had been pickled and smoked until there could be no suspicion of a nervous influence left, would, when sufficiently pliable, produce the sound, the cuticle being used next the plate.

While Prof. Tyndall's experiments did not explain what the cause of the phenomenon really was, they determined most conclusively that it was not due to nervous influence upon the tissues, acting in sympathy with electrical impulses. It was suggested by some that it might be caused by electrical discharges, in the form of a spark, from the hand to the plate; but if this is true, why should motion as a gliding of the hand over the surface of the plate, be necessary to

produce the result? Others have suggested that the molecules of the substance in contact were disturbed upon the passage of such electrical impulse, roughening the surface, and for the instant producing a sudden increase of friction. If this is true, why should wetting the parts in contact destroy the effect?

But to continue my experiments: I noticed that when revolving the plate with my finger in contact, the friction was greater when a note was sounding. I then connected a small Ruhmkorff coil to a battery, inserting a common telegraphic key in the primary circuit, instead of the self-acting circuit-breaker. I connected one end of the secondary coil to the metal plate and holding the other end in my hand, I rubbed the plate briskly, and had my assistant slowly make dots with the key. I noticed at each make of the circuit a slight sound and at each break a very much louder one, owing to the fact that the terminal secondary wave is much more intense than the initial. I now held my hand still, and, while I could feel the shock just as distinctly as before, there was no audible sound, proving that the motion was a necessary condition in its production. The sensation when the sound was produced was as though my finger had suddenly adhered to the plate, and then as suddenly let go, producing a sound.

The next experiment was with one hundred cells of gravity battery. I connected one pole to the plate and held the other in my hand, pressing my finger against the plate and revolving it as before. I inserted a thin piece of paper between my fingers and the plate to prevent painful effects from the current, and my assistant made dashes with a key in the circuit. I was thus able to notice the effect of an impulse of longer duration. When the key was closed there was a perceptible increase of the friction, so that my finger took a position farther forward on the plate, where it would remain as long as the circuit remained closed. As soon as the key was opened my finger suddenly dropped back on the plate, making the same noise I had before heard. This operation was repeated so often that there could be no question as to the effect it produced.

From the foregoing experiments, I find that the following conditions are necessary to reproduce musical tones through the medium of animal tissue, by means of electric waves transmitted through a telegraph wire.

1st. The electrical impulses must have considerable tension in order to make the effect audible.

2d. The substance used for rubbing the receiving plate must be

soft and pliable, and must be a conductor of electricity up to the point of contact, and there a resistance must be interposed, very thin, neither too great nor too little.

3d. The plate and the hand or other tissue must not only be in contact, but it must be a rubbing or gliding contact.

4th. The parts in contact must be dry, in order to preserve the necessary degree of resistance.

It will be seen that we have here the conditions of a static charge, the plate receiving one polarity from the battery, and the hand the other polarity, the interposed resistance preventing in a great degree the dynamic effect. It is a well-known fact that two bodies statically charged with opposite electricities attract each other. May not this be the whole solution of the phenomenon, that each wave as it arrives at the receiving end becomes for a moment static, which results in a momentary attraction between the plate and the finger and this immediately ceasing when the wave is gone, releases the finger with a noise or sound. If, then, sounds are repeated as fast as the sending reed vibrates, the production of a musical tone must follow according to well known laws of acoustics, providing the waves are sent to line in musical order.

In the winter of 1873–4, I experimented very elaborately and worked out many new applications of the principle, not only to transmission of music, but to the transmission of telegraphic messages.

If, instead of the revolving plate and the animal tissue we place in the circuit an electro-magnet, or a number of them, and have a tune played at the transmitting end, the tune will be heard from all these electro-magnets. The music produced will be loud or low; 1st. As the battery used is strong or weak; 2d. As the line offers more or less resistance; and 3d. As the magnets are mounted more or less favorably for acoustic effect.

In this case, as in that of the animal tissue, each impulse produces a sound; but it is produced differently in the two. It is a well known fact that an iron rod elongates when magnetized and contracts again when demagnetized. The elongation and contraction are so sudden, that an audible sound is produced at each change. In order to convert this sound into musical tone, it is only necessary to repeat it uniformily and at a definite rate of speed, which shall not be less than sixteen nor more than four thousand per second.

When the electro-magnet is properly mounted, the tone may be made very loud. Fig. 3 shows a very good form for mounting the

magnet for receiving the music. It is a common electro-magnet having a bar of iron rigidly fixed at one pole, which extends across the other pole, but does not touch it by about one-sixty-fourth of an inch. In the middle of this armature a short post is fastened, and the whole mounted on a box made of thin pine, with openings for acoustic effects.

One of the earliest discoveries with this experiment was the fact that not only simple but composite tones could be sent through the wire and received, either on the metal plate or on the magnet. Not only could a simple melody be transmitted, but a harmony or discord could be equally well. From that time I have worked assiduously with the view of making a rapid telegraphic system embodying this discovery. The first step was to analyze the tones at the receiving end, which if successfully accomplished, would open the way to a multiple Morse, a fast printing, an autographic and other systems.

It would be impossible to give in this paper all the experiments tried, for there were very many indeed. I accomplished the analysis in a number of ways. The method which seemed in all respects to give the best satisfaction is as follows:

Fig. 4. is a perspective of one form of a receiving instrument called an analyzer. The construction of the instrument is very simple. It consists of an electro-magnet adapted to the resistance of the circuit where it is intended to be used, and of a steel ribbon strung in front of this magnet in a solid metal frame, and provided with a turning screw at one end so as to readily give it the proper tension. The length and size of the ribbon depend upon the note we wish to receive upon it. If it is a high note, we make it thinner and shorter, if a low note, we make it thicker and longer. If this ribbon is tuned so that it will give a certain note when made to vibrate mechanically, and the note which corresponds to its fundamental is then transmitted through its magnet, it will respond and vibrate in unison with its transmitted note, but if another note be sent, which varies at all from its fundamental, it will not respond. If a composite tone is sent, the ribbon will respond when its own note is being sent as a part of the composite tone, but as soon as its own tone is left out it will immediately stop. Thus I am able to select out and indicate when any note is being sent, in fact, to analyze the tones which are passing over the line.

This method of analyzing tones transmitted through a wire elec-

trically is analogous to Helmholtz's method of separating tones transmitted through the air.

The transmitting instruments used in sending composite tones are made similar in every respect to the one *s* own in Fig. 1 *a*, except that each reed is separately mounted. A cut of one of these transmitters, used in telegraphic work, is shown in Fig. 5.

Fig. 6 shows a diagram view of two transmitters and two receivers with their connections. The local circuits with their magnets, are left off to avoid confusion.

A and B represent two transmitters, placed at one end of a line; A′ and B′, two receivers at the other end. One end of the main battery is connected to line, and the other end to ground. Each transmitter is placed in a shunt wire running from its main battery connections around one-half of the battery. A common open circuit key is placed in each of these shunt wires. Suppose, now, the two reeds A and B, A making 264 vibrations per second, and B 320, just two tones or a major third above A. So long as the keys remain open, the battery is all on the line steadily. If the key of transmitter A is closed, half of the battery is being thrown on and off the line at a rate of 264 times per second. This causes a succession of electrical waves to flow through the line at the same rate. If now the steel ribbon of the analyzer A′ has been tuned in unison with these electrical waves, it will respond and hum the same note as the transmitter; but if it is not in unison, it will remain practically quiescent, so that the note can only be heard by submitting it to the most delicate test. To bring them in unison, it is only necessary to turn the tuning-screw up or down, as the case may be. When the fundamental of the ribbon corresponds with that of the sending reed, it announces the fact by sounding out loud and full. If (having the key of transmitter A still closed, and consequently its corresponding analyzer still sounding) we close the key belonging to transmitter B, the other half of the battery will be thrown on and off the line, at the rate of 320 times per second, and another succession of electrical waves will flow through the line, this one being at the rate of 320 times per second. If the analyzer B′ is in proper tune, so that its fundamental is the same as that of its corresponding transmitter B′ it will hum its note as long as the key is closed, making a chord with A′. In the same way, a great number of different notes may be sounding at the same time, at one end of a telegraphic line, and be heard simultaneously at the other end, each note sounding upon a different receiving instrument.

The manner of making these vibrations of the analyzer operate a sounder, a register, or other recording instrument, is shown in the detached section of the analyzer, at Fig. 7. In this case *a* is a short section of the steel ribbon, *b* the electro-magnet, C a light metal bar pivoted at E, D a platinum point resting against another on the ribbon *a*, and *f* an adjusting spring by which the pressure of lever C, at the point D, agalnst the ribbon *a*, is regulated. One pole of the local battery is connected to the steel ribbon, through the frame of the instrument. The other runs through the sounder-magnet G, and thence to the lever C, completing the circuit at the point D. The tension of the spring *f* is so regulated that the rate of vibration of the lever C is naturally slower than that of the ribbon *a*. The operation is as follows: When the operator at the sending station closes his key, the ribbon *a* is thrown into vibration, and remains so as long as the key continues closed; but comes to rest immediately when the key is opened. The lever C, not being able to follow the ribbon, rattles against it with a buzzing sound, disturbing the continuity of the local circuit by throwing in a great resistance at the point D. This resistance is sufficient to act upon the sounder the same practically as dead break. By this means the sounder is made to follow the key of the operator who is sending the proper note. In the same manner all the other tones may be brought into service, each ignoring the other, and each seeking its own at the receiving end.

By this method, not only may different messages be sent simultaneously, but a tune with all its parts may be sent through hundreds of miles of wire, and be distinctly audible at the receiving end.

A successful experiment was made at Milwaukee, Wis., on January 8th, 1876, with Mr. Gray's system. A loop was arranged by way of Horicon to Portage and back by way of Watertown, a distance of 200 miles. Over this single wire eight operators sent messages and signals in the same direction at the same time, without any one interfering with another. The experiment was witnessed by a number of telegraphers and representatives of the press.

(No. 36.) Defendants' Exhibit, Dr. Van Der Weyde's Second Article.

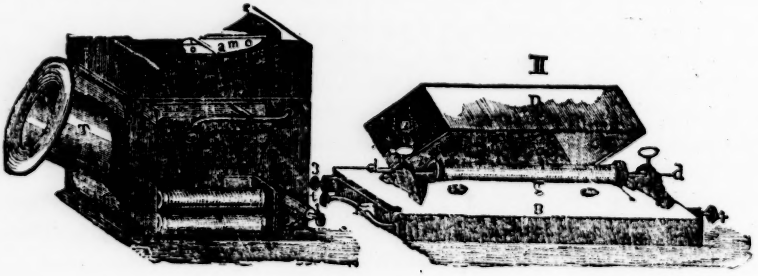
Scientific American, March 4, 1876.

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 9.]

THE INVENTION OF THE TELEPHONE. BY P. H. VAN DER WEYDE, M.D.

In connection with Mr. Gray's application of the telephone to the simultaneous transmission of several different telegraphic messages over one wire at the same time, and his paper read before the American Electrical Society (published on page 92, Scientific American supplement for Feb. 5), it may be interesting for the readers of this paper to obtain some information in regard to the invention of the telephone, by Reuss. As mentioned in the article above referred to, Page and Henry observed that, by rapid magnetization and demagnetization, iron could be put into vibrations isochronic with the interruptions of the current; and later, Marian experimented extensively in this direction, while Wertheim made a thorough investigation of the subject, which induced Reuss, of Friedrichsdorf, near Hamburg, Germany, to apply this principle to the transmission of musical tones and melodies by telegraph; and he contrived an apparatus which we represent in the engravings.



Professor Reuss's Telephone.

The telephone of Reuss consists of two parts, the transmitting and the receiving instrument. Fig. I. represents the former, and is placed at the locality where the music is produced; Fig. II., the latter, is placed at the station where the music is to be heard, which

may be at a distance of one hundred, two hundred, or more miles, in fact, as far as the battery used can carry the current, while the two instruments are connected with the battery and the telegraph wire in the usual manner. One pole of the battery is connected with the ground plate, the other with the screw, marked 2 of Fig I., and thence over a thin copper strip *n*, with a platinum disk, *o*, attached to the centre of the membrane stretched in the large top opening of the hollow and empty box, K, intended to receive and strengthen the vibrations of the air, produced by singing before the funnel-shaped short tube attached to the opening in T. Over the platinum disk, *c*, attached to the elastic membrane, is a platinum point attached to the arms *b c* and *b* K, while a set screw brings this point in slight contact with the platinum disk mentioned, a part of the box is represented as broken and removed in order to show the internal construction. The strip *a b c* is connected with the end *s*, of the switch *t s*, and the screw connection, 1, at the lower right hand corner, and also through the telegraph wire, to the instrument Fig. II., at the receiving station, which may be situated at a distance of many miles. Here the current enters by the screw connection 3, and passes through the spiral *g*, surrounding the soft iron wire, *d d*, of the thickness of a knitting needle, and leaves the apparatus at the screw connection, 4, whence it obtains access to the ground plate, and so passes, through the earth back to the battery. The spiral and iron wire *d d* is supported on a hollow box B, of thin board; while a cover D, of the same material is placed on top, all intended to strengthen the sound produced by the vibrations which the interruption of the current caused in the iron wire *d d*, so as to make these vibrations more audible by giving a large vibratory surface, in the same way that the sounding board of a pianoforte strengthens the vibrations of the air, caused by the strings, and makes a very weak sound quite powerful.

If a flute be played before the opening T, or if a voice be singing there, the vibration of the air inside the box K, causes the membrane *m* to vibrate synchronically, and this causes the platinum disk *o* to move up and down with corresponding frequency. At every downward motion the contact of this disk with the platinum point, under *b*, is broken, and therefore the current is interrupted as rapidly as the vibrations occur. Let, for instance, the note C be sounded; this note makes sixty-four full vibrations in a second, and we have, therefore, sixty-four interruptions of the electric current, which interruption will at once be transmitted through the tele-

graph line to the receiving instrument, and put the bar *d d* into exactly the similar vibrations, making the very same tone C audible; and so on for all other rates of vibration. It is clear that in this way not only the rhythm of music can be transmitted (and this can be done by the ordinary telegraph), but the very tones, as well as the relative durations and the rests between them can thus be sent, making a full and complete melody. The switch *t s*, Fig. I., is intended, in connection with a similar one in Fig. II., to communicate between the stations with the help of the electro-magnet E E, to ascertain if station Fig. II. is ready to receive the melodies; then it gives the signal by manipulating the switch, which is received by the attraction of the armature A, the latter arrangement being a simple Morse apparatus attached to the telephone.

Professor Heisler, in his "Lehrbuch der technischen Physik" (3d edition, Vienna, 1866), says, in regard to this instrument: "The telephone is still in its infancy; however, by use of batteries of proper strength, it already transmits not only single musical tones, but even the most intricate melodies, sung at one end of the line to the other, situated at a great distance, and makes them perceptible there with all the desirable distinctness." After reading this account in 1868 I had two such telephones constructed, and exhibited them at the meeting of the Polytechnic Club of the American Institute. The original sounds were produced at the further extremity of the large building (the Cooper Institute), totally out of hearing of the Association, and the receiving instrument, standing on the table in the lecture room, produced (with a peculiar and rather nasal twang) the different tunes sung into the box K, at the other end of the line; not powerfully, it is true, but very distinctly and correctly. In the succeeding summer I improved the form of the box K, so as to produce a more powerful vibration of the membrane, by means of reflections effected by curving the sides; I also improved the receiving instrument by introducing several iron wires in the coil, so as to produce a stronger vibration. I submitted these, with some other improvements, to the meeting of the American Association for the Advancement of Science, and on that occasion (now seven years ago) expressed the opinion that the instrument contained the germ of a new method of working the electric telegraph, and would undoubtedly lead to further improvements in this branch of science, needing only that a competent person give it his undivided attention, so as to develop out of it all that it is evidently capable of producing.

Before leaving this subject, I wish to draw special attention to the fact that the merits of the invention consist chiefly in the absence of musical instruments, tuning forks, or their equivalents for producing the tones; any instrument will do: flute, violin, human voice, etc. If the aerial vibrations are only conducted into the box, Fig. I, the apparatus will send the pitch as well as the duration of the different tones, with the rests between, therefore not only transmitting perfect rhythm, but a complete melody, with its long and short notes. The two parts of the apparatus may even be connected each to a separate piano-forte; and if this were done in a proper manner a melody played on the piano-forte connected with the transmitting instrument, Fig. I., would be heard in the piano-forte at a great disatnce, connected with the receiving instrument, Fig. II.

1136

(No. 37) Defendants' Exhibit, Extract from Publication entitled "Electric Telegraph," by Dr. Lardner, pages 164–167.

J. A. W., Examiner.

[Introduced in Record, p. 10.]

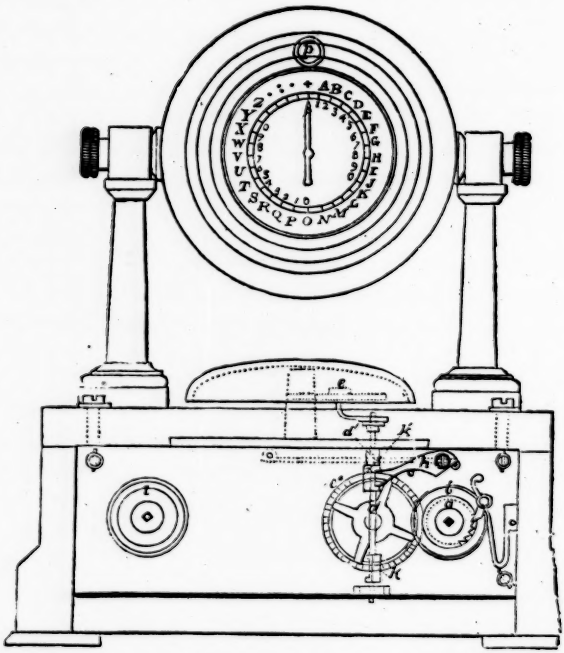


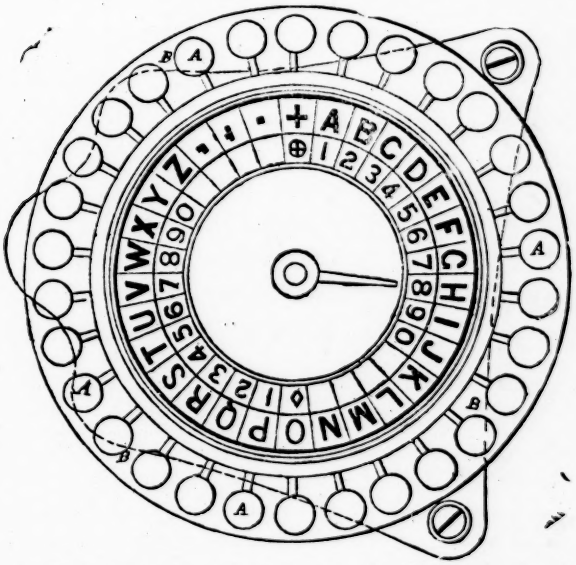
Fig. 109.—Professor Wheatstone's Alphabetical Instrument—Receiving Apparatus and Alarum.

"WHEATSTONE'S ALPHABETICAL INSTRUMENT.

"152. The various step by step, or letter-indicating, telegraphs may be said mainly to owe their origin to Professor Wheatstone, whose early labors were mostly in this direction, and who has gradually perfected his apparatus until it has assumed the form now so extensively used for domestic purposes, and especially for communicating between offices, warehouses, &c. The advantage of this class of telegraph is, that those unaccustomed to its use can read the letters as they are successively indicated by the revolving pointer of the receiving apparatus; and, after a very short experience, can in like manner signal the letters with the sending keys.

"From the nature of this form of instrument, and from a large number of currents required for each letter on an average, it is slower in operation than the needle, acoustic or recording telegraphs. For the reason, combined with the difficulty of working it on any circuit of considerable length, the step-by-step indicating telegraphs have been pretty much restricted to the applications already mentioned.

"In 1858, Professor Wheatstone, patented a series of improve-


A
B
A
A
B
A
B
A
A
B
A
B
A
A
B

"The arrangement of this apparatus is shown in Figs. 109, 110, 111 and 112.

"Fig. 110 is a vertical view of the outside of the sending apparatus, showing the small finger studs A A (thirty in number), which, when pressed down, allow such a succession of currents to pass to the distant station, as will move round the indicator on the receiving dial to the corresponding letter.

"Fig. 111 is a section (side view) of the sending apparatus. The handle *x* is used to turn a pair of electro-magnetic coils (*bb*) by an endless band, rapidly above the poles of a permanent steel magnet *a*. A succession of magnetic currents are thus sent, and as long as the handle is turned and the small finger studs unmoved, the indicators of the receiving dials move on step by step. On one of the

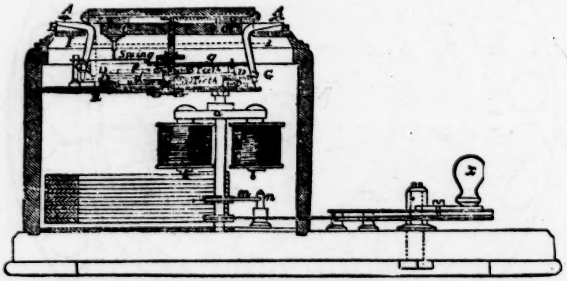


Fig. 111.—Prof. Wheatstone's Alphabetical Telegraph Sending Apparatus (Section).

studs A, being depressed to the stop B, the movement of the arm *g* is arrested as soon as it comes round to the lower end G of the finger-key, and the circuit is broken; no further effect being then produced on the indicating instruments, its pointer indicates the letter upon the dial to which attention is directed by the pause. An arrangement is made by which, when a stud is depressed, it remains down until another is pressed, upon which the first is mechanically returned to its former position.

"Figs. 109 and 112 show the indicating apparatus and alarum. The index pointer is moved round by a pallet wheel acted upon by the alternate attraction and repulsion of two magnetic needles *h h*

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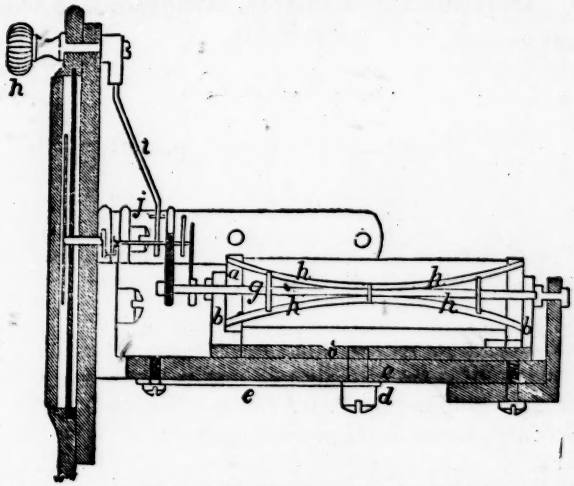

Fig. 112.—Prof. Wheatstone's Alphabetical Instrument—Indicating Apparatus (Section).

fixed upon an axis *g* by the currents passed from the sending apparatus through the electro-magnets in the receiving instruments.

"*b c d e* form the bearings, and *h i j* is an external regulator."

3140

(No. 38) Defendants' Exhibit, American Association on Reis.

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 10.]

Proceedings American Association for the Advancement of Science. Meeting at Salem, August, 1869.

In the list of papers read is the following:

"On the audible transmission of musical melodies by means of the electric telegraph. By P. H. Van der Weyde."

(*Article not printed in the proceedings.*)

(No. 39) Defendants' Exhibit, Extract from "The Telegraphic Journal and Electric Review," Vol. 3, No. 69, December 15, 1875, pp. 286-288.

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 10.]

TRANSMITTING MUSICAL TONES BY ELECTRICITY. BY ELISHA GRAY, OF CHICAGO.

This is a method of producing musical tones of any desired pitch at any point in an electrical circuit, and consists in transmitting

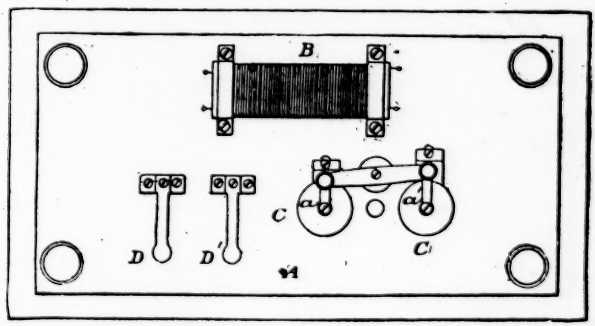

Fig. 1.

a series of impulses of induced electricity of high tension, corresponding in number to the number of audible vibrations constituting the said musical tone, through living tissue in contact with any resonant substance or through a coil surrounding a bar of iron or the core of an electro-magnet, the succession of currents being produced by an induction coil or other aparatus for inducing a secondary current, and being caused by the action of any suitable circuit interrupter situated in a primary circuit (taken from the specification).

And in order that the said invention may be fully understood, I shall now proceed more particularly to describe the same, and for that purpose shall refer to the several figures, the same letters of reference indicating corresponding parts in all the figures.

Figure 1 of the drawings represents one form or plan of an electrical apparatus in which these improvements are embraced; Fig. 2 is a front elevation of the same, and Fig. 3 is a diagram

showing an arrangement of parts and circuits which may be employed in connection with these improvements.

A represents the base or frame of the apparatus; B is an induction coil of the usual form, provided with the usual primary and secondary helices; C is an ordinary vibrating electrotome which, when in action, produces a musical tone by the vibration of its armature and circuit-breaking spring *a* of a pitch determined by its weight of vibration, which rate is dependent upon the length, stiffness and adjustment of the spring attached to the armature of the electrotome; C′ is another electrotome similar to the first, with the exception that its spring *a′* is so adjusted that it produces, when in action, a musical tone of a different pitch from that produced by the electrotome C, owing to the different rate of vibration of its circuit-breaking spring *a′*. Other electrotomes may be provided, having their vibrating springs so constructed and adjusted that when in action the series will produce tones extending through one or more octaves. These electrotomes are situated in the primary circuit of the induction coil B, and when the said primary circuit is broken by the vibration of the circuit-breaking springs, secondary currents are induced in the secondary circuit of the said coil.

D, D′ are telegraphic keys of the usual form placed in the primary circuit above referred to, which circuit is divided so that it passes through both keys and both electrotomes. The keys are used for making connection with the battery.

Figures 3 and 4 show the arrangements of the circuits; G being the secondary circuit, extending from the induction coil B to the receiving station; F the battery, and H the primary circuit from the battery through the keys; D, D′, magnets of the electrotomes C, C′, and the primary circuit of the induction coil B. E represents a suitable resonant substance at the receiving station, and consists of a hollow cylinder of metal.

The method of operation of the apparatus is as follows: On depressing either of the keys D, D′, the primary circuit from the battery F will be closed through one of the electrotomes, and the spring or circuit interrupter of the latter will immediately commence to vibrate, producing a musical tone of a certain pitch, dependent, as before stated, on the size and adjustment of the spring, and interrupting the primary circuit of the induction coil B; these interruptions will induce secondary currents in the secondary circuit of the said coil, which will correspond in number with the vibrations

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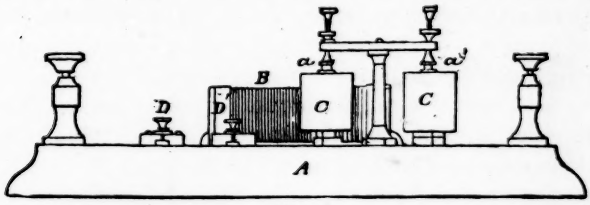

Fig. 2.

of the circuit interrupted, and the number of musical audible vibrations constituting the tones produced. Thus, for example, if the circuit-interrupting spring vibrates one hundred and twenty-eight times per second, the tone produced is that known as the "fundamental C," and at the same time one hundred and twenty-eight terminal induced currents will be generated in the secondary circuit.

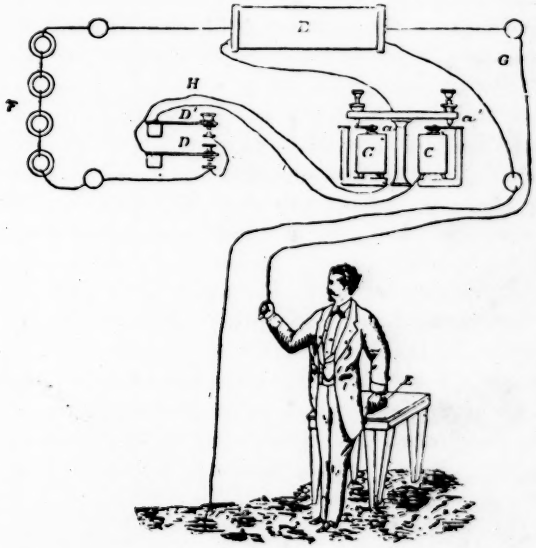

Fig. 3.

If now a person places himself in the said secondary circuit and brings his hand or any other part of his body in contact with any resonant substance, which is a conductor of electricity, so that the circuit is completed through it, the said resonant substance being either the metallic cylinder shown at E, or a plate of metal stretched above

the body of a violin by metallic strings, or a sheet of foil paper stretched over a metallic ring, or any other suitable resonant substance, the impulses of electricity transmitted through the living tissue of the operator will, from some cause not yet fully understood, produce a corresponding number of vibrations in said resonant substance and a musical tone will be given forth of a quality dependent upon the character of the resonant substance, but of the same pitch as that produced by the vibration of the circuit interrupter at the transmitting end.

Instead of interrupting the primary circuit by vibrating automatic electrotomes, and thereby inducing the secondary current of high tension which is transmitted to the resonant receiver, the necessary interruptions for this purpose may be effected by any mechanical device which will produce a sufficient number of interruptions per second to cause a musical tone.

The secondary coil may be dispensed with, and the secondary currents induced in the primary coil, when the primary circuit is interrupted, may be transmitted to the receiver for the purpose of producing the audible vibrations.

Another form of the apparatus is constructed as follows: The transmission of sound is effected, as in the apparatus above described, by the conversion of electrical impulses of high tension through a secondary circuit into audible vibrations, but the apparatus is based upon the principle that an electrical current, traversing a coil surrounding a bar of iron or a coil of an electro-magnet, causes a slight elongation of the said bar or core, which elongations, if they succeed each other with sufficient rapidity, will result in a vibration of the bar and the production of a musical tone. This apparatus is shown at Fig. 4, the transmitting apparatus being the same as in the apparatus before described, but the receiving apparatus, as shown at E, consists of an electro-magnet placed in the secondary circuit. S represents a hollow cylinder of metal,

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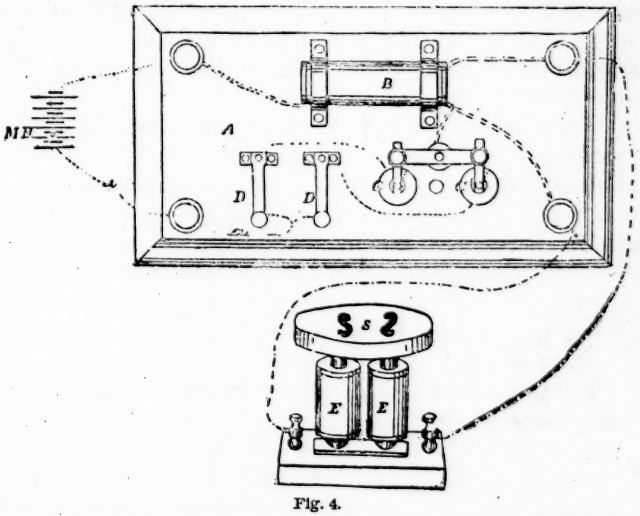


Fig. 4.

which is placed upon the poles of the electro-magnet and intensifies the sound.

The uses to which the apparatus may be applied are various. In telegraphing, for example, instead of transmitting messages by means of the Morse alphabet, now in general use, tones of different pitch corresponding to the letters may be employed, which tones can be produced more rapidly than printed or impressed dashes can be made, and there duration would be shorter than the intermission now required for producing dashes and dots in succession.

A very slight interval would be necessary between the tones to indicate the separation, and, as dashes would be indicated by one tone and dots by another, all signals would have the same length. Instead of using one tone for dashes and another for dots, signals could be devised consisting of tones of various combinations. These signals can soon be readily learned and read by any operator capable of distinguishing tones of different pitch, who, by placing his ear in contact with the resonant substance, would cause the tones to be produced, and still have both hands free to receive the message. By means of a type-writer an operator could record eighty words a minute.

The amount of current which is necessary to produce the effect is almost unappreciable. Less than one-hundredth part of the

battery power now required enables audible signals to be transmitted over long lines. The apparatus can, therefore, be employed with advantage on submarine lines, and the rate of transmission over them can be thereby much increased.

As a telegraph apparatus, it is simple, economical and rapid in its operation.

The apparatus may also be employed to transmit tunes from one place to another; the vibrating pieces being properly pitched and sufficient in number, even the different parts of a musical composition, each simultaneously played in different places, may be transmitted to the same place, so that the whole will be there audible. In the latter case a separate circuit and transmitting and receiving apparatus will be required for each part of the musical composition, and it will be necessary to beat time by telegraph for each set of performances.

(No. 40.) Defendants' Exhibit, Edison Relay-Magnet Patent.

J. A. W., Exr.

[Introduced in Record, p. 10.]

THOMAS A. EDISON, OF NEWARK, NEW JERSEY, ASSIGNOR TO HIMSELF AND GEORGE HARRINGTON, OF WASHINGTON, DISTRICT OF COLUMBIA.

IMPROVEMENT IN RELAY-MAGNETS.

Specification forming part of Letters Patent No. 141,777, dated August 12, 1873; application filed March 13, 1873.

To all whom it may concern:

Be it known that I, Thomas A. Edison, of Newark, County of Essex and State of New Jersey, have invented an inprovement in telegraphic instruments, of which the following is a specification:

Relay-magnets are employed to a large extent in various telegraphic operations. It is, however, found that the adjustment of the springs that draw back the armature and the burning of the contact points by the spark are sources of constant annoyance.

My present invention is made for preventing the points burning out, and for avoiding adjustment of the retractile armature springs.

I make use of metallic contact points within a liquid, such as glycerine or water, so that the motion of one contact point nearer to or farther from the other raises and lowers the electric tension in the telegraph line, and operates a distant magnet without forming a spark or breaking the circuit.

In the drawing, figure 1 is a side view of the relay-magnet with the circuit cup in section, and figure 2 is a side view of the distant magnet.

The finger key *a*, is in a circuit from the battery *b*; so also are the coils of the relay-magnet *c*. The armature *d* and its lever *f* are moved by the spring 3 in one direction, and by the magnet *c* in the other. The circuit cup *g* is made to contain water, glycerine or other suitable liquid. In the bottom is the screw or point *i*, connected with the circuit wire *k*, and the movable point or screw *l*, passing through the lever *f* is connected with the other circuit wire *m*, extending to the distant magnet *n* (the battery *r* is in the circuit

7148

to the magnet *n*), and it will now be understood, that by adjusting the point *l* nearer to or farther from *i* the proportion of current passing to the magnet *n* can be adjusted so that, when the point *l* is moved by the magnet *c* nearest to *i*, the current from *r* will be sufficiently powerful to energize the magnet *n* and draw down its armature *u*; but when the circuit to the magnet *c* is broken at the key *a*, or otherwise, the moving of the point *l* away from *i* will lessen the tension in the circuit *k m* by the resistance of the intervening liquid, and weaken the power of the electro-magnet *n*, so that its spring or weight will draw away its armature.

The movement of the armature *u* may be made operative in effecting any desired telegraphic operation to which it is adapted. I, however, employ the same especially as a sounder, and in that case the battery *r* and circuit *k m* are local.

I am aware that contact points within a liquid, such as oil or glycerine, have been employed in the circuit breaker of an electric engine. In my improvement the circuit is not broken, but the relay-magnet or sounder is operated by rise and fall of tension, and the contact points are adjustable, instead of varying the armature spring of the magnet.

I claim as my invention:

The adjustable contact-points, acting within a liquid, in combination with a helix, armature, and spring of a sounder or relay, as set forth.

Signed by me this 7th day of March, A. D. 1873.

THOMAS A. EDISON.

Witnesses:

GEO. T. PINCKNEY,

CHAS. H. SMITH.

2149.

T. A. EDISON.

Relay Magnets.

No. 141,777. Patented August 12, 1873.

Fig. 1.

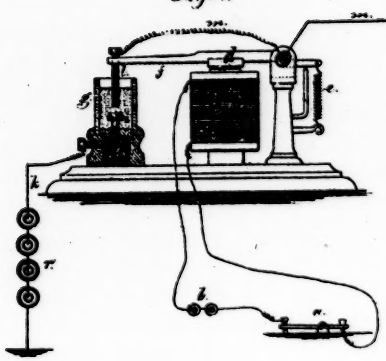
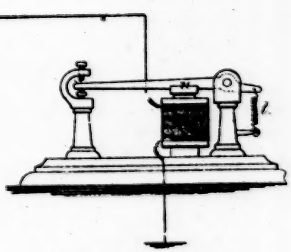


Fig. 2.



Witnesses,
Chas. A. Smith
Geo. D. Talbot.

Inventor
Thomas A. Edison
Lemuel W. Serrell
Atty.

2150

(No. 41.) Defendants' Exhibit, "Gray's Animal Tissue Patent."

J. A. W. Ex'r.

[Introduced in Record, p. 10.]

ELISHA GRAY, OF CHICAGO, ILLINOIS, ASSIGNOR OF ONE-HALF HIS RIGHT TO SAMUEL S. WHITE, OF PHILADELPHIA, PENNSYLVANIA.

IMPROVEMENT IN ELECTRIC TELEGRAPHS FOR TRANSMITTING MUSICAL TONES.

Specification forming part of Letters Patent No. 166,096, dated July 27, 1875; Application filed January 19, 1875.

Case 1.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illionis, have invented a new and useful Art of Transmitting Musical Impressions or Sounds Telegraphically, as well as certain new and useful Improvements on Apparatus for so Transmitting such Impressions or Sounds, of which Art and Apparatus, I hereby declare the following to be a full, clear, and exact description.

My invention relates to a novel art of transmitting musical impressions or sounds telegraphically, which impressions or sounds may be utilized as signals for the transmission of intelligence.

My invention is based upon the well-known law of acoustics that bodies vibrating with different rapidity produce tones of different pitch, and upon my own discovery that such vibrations can be transmitted through a telegraphic circuit and reproduced in a musical tone or note of a pitch corresponding with that originally transmitted by including in the circuit animal tissue or other equivalent substance, which will cause a slight resistance to the electrical current, at the point of contact between such animal tissue and some resonant conductor of electricity.

My improvement consists in a new and useful art of producing musicial impressions or sounds at the transmitting end of a telegraphic circuit, by causing interruptions in the electric currents of

7151.

sufficient frequency to produce musical tones, transmitting said tones through an electric circuit composed in part of animal tissue, and reproducing them at the receiving end of the line, by means of a resonant body which is also a conductor of electricity.

My improvement further consists in a new and useful apparatus for carrying out the objects of my invention, which apparatus consists of the combination of a telegraphic circuit composed in part of animal tissue, a circuit-breaker capable of producing a musical tone, and a receiver capable of reproducing that tone at the receiving end of the circuit.

My improvement further consists of the combination, in an apparatus such as described, of a series of circuit-breakers capable of producing musical tones of different pitch, and a series of keys for simultaneously or successively throwing the circuit-breakers into or out of operation, whereby several tones simultaneously or successively may be transmitted through a single wire.

The subject: matter claimed will hereinafter specificially be designated.

In the accompanying drawings, Figure 1 represents a plan or top view of a portion of the transmitting apparatus. Figure 2 is a front elevation of the same, and Figure 3 a diagram, showing an arrangement of parts, and circuits which advantageously may be employed in working my invention.

The transmitting apparatus is mounted, as usual, upon a base board, A. An induction-coil B′ is provided with primary and secondary helices of the usual construction. A common vibrating electrome, C, having its circuit breaking spring *a* of such length, thickness, and adjustment that its vibration produces a musical tone of a certain pitch, forms part of the circuit.

It is obvious that the apparatus may be worked with a single electrome, the pitch of which may be varied by adjustment; but where a series of tones of different pitch is desired, I prefer to employ a series of electrotomes having different rates of vibration.

Two electrotomes, C C′, of identical construction, but differing in pitch, are shown in the drawings; but I propose, under some circumstances, to use a series of electrotomes which will give tones extending through one or more octaves. These electrotomes are, by preference, placed in the primary circuit of the induction-coil, and, when in operation, induce secondary currents or impulses in the secondary circuit of said coil, equal in number to the vibrations of the circuit-breaking spring of the electrotome.

2152

An ordinary telegraph-key situated in the primary circuit, opens or closes the connections of the battery. Each electrotome must have a corresponding key. In the drawings, two keys, D D′, are shown, both of which, as well as the electrotomes, are situated in the primary circuit, which is divided or branched in order to pass through them.

Figure 3 shows the arrangement of the circuits. The primary circuit F, connected with the battery E, passes through the keys D D′, the magnets of the electrotomes, and the primary circuit of the induction-coil B. One terminal of the secondary circuit G, extends from the induction-coil to the receiving station through animal tissue to a suitable resonant conductor of electricity, which, is, in this case, a hollow metallic cylinder, H, which is connected with the ground. The other terminal, I, of the induction-coil passes directly to the ground in the ordinary way.

The animal tissue interposed between the wire, and the resounding receiver to complete the circuit, is shown in the drawings as consisting of the body of the receiving operator, who must be insulated from the ground; but other substances may be employed, which must possess the specific characteristics of being conductors of electricity, of being yielding and elastic, and of having a surface of greater electric resisting capacity than its interior.

These characteristics are found in the skin of the human body, in leather moistened with acidulated water, in animal flesh covered with a membraneous coating, in bacon-rind, in pork skin, especially pieces taken from the ear or tail, in kid gloves, and in other substances which need not be enumerated, as they do not operate so perfectly as those above given.

The operation of the apparatus is as follows: The closing of either of the keys completes the primary circuit from the battery through the electrotome connected with the key depressed, and the circuit closing spring of said electrotome will immediately be thrown into rapid vibration, and a musical tone of a certain pitch dependent upon the length, thickness and adjustment of the spring will be given forth; while, at each vibration, the current in the primary circuit of the induction apparatus will be interrupted. These interruptions produce corresponding secondary currents or impulses in the secondary circuit of the induction apparatus, and these secondary induced currents or impulses are transmitted to the receiving station. Thus, for example, if the circuit-breaking spring of the electrotome vibrates one hundred and twenty-eight times per

2153

second, the tone given forth is that known as the "fundamental C," while one hundred and twenty-eight terminal secondary currents or impulses will be induced in the secondary circuit of the induction apparatus, and transmitted through the animal tissue above mentioned, forming part of said circuit, to the resonant receiver, and will, from some cause not understood or explicable in the present stage of the art, vibrate the same synchronously with the transmitting electrotome, and thus give forth a musical tone of the same pitch.

A metallic plate, stretched by metallic strings above a sounding-board—such, for instance, as the body of an ordinary violin—may be used with good effect to receive the vibrations, instead of the hollow cylinder above described.

From the foregoing description it will be seen that musical tones produced at the transmitting stations can simultaneously be produced at the receiving station, however distant. When two or more keys are simultaneously or successively depressed, corresponding tones will simultaneously be transmitted, thus producing harmony or melody.

The interruptions in the primary circuit which cause the induced secondary currents or impulses may be produced by a mechanical circuit-breaker having the requisite rapidity of motion, such as a revolving wheel or revolving brush; or they may be produced by providing the vibrating reed or reeds of an organ with contact points, so that, as the reed vibrates, it will transmit impulses corresponding in number per second to the number of vibrations per second of the notes sounded by the organ pipe.

I prefer to use the impules of the induced secondary currents as the transmitting medium, as such use affords the most convenient way of obtaining electricity of high tension, which is that best adapted for penetrating a slightly resisting medium, such as the animal tissue hereinbefore mentioned.

The secondary coil is not essential, as the secondary circuit induced in the primary coil may be utilized for transmitting the signals.

My improvement enables me to operate with a very slight amount of current, as the battery power required to produce and transmit the vibrations is less than one hundredth part of the battery power now required to transmit signals over long land lines.

My improved method can advantageously be substituted for the Morse telegraph alphabet now in general use, as an alphabet can

3154

be constructed on the principle of using tones of different pitch for the different letters, which will admit of great rapidity of transmission.

By means of my improved apparatus, not only may a tune be transmitted by a single operator to a distant point, but the different parts of such tune simultaneously may be reproduced at a common point from different places, a separate part of the tune being played at each place.

The apparatus can also advantageously be employed in studying acoustics and the physical theory of music.

The combination, with a main line, of an intermittent circuit-breaker, or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for and controlling each such circuit-breaker, are not broadly claimed herein, as they constitute a part of the subject matter of another application for Letters Patent of the United States, filed by me February 23, 1875.

I claim as my invention:

1. The hereinbefore described art of transmitting musical impressions or sounds telegraphically by producing musical impressions or sounds at the transmitting end of a telegraphic circuit by causing interruptions in the electric currents of sufficient frequency to produce musical tones, transmitting said tones through an electric current composed in part of animal tissue, and reproducing them at the receiving end of the line by means of a resonant body, which is also a conductor of electricity, substantially set forth.

2. The electro-harmonic telegraph apparatus hereinbefore set forth, consisting of the combination of a telegraph circuit composed in part of animal tissue, a circuit breaker capable of producing a musical tone, and a resonant conductor of electricity capable of reproducing that tone at the receiving end of the circuit.

3. The combination, substantially as hereinbefore set forth, of a telegraphic circuit composed in part of animal tissue, a resonant receiver, which is also a conductor of electricity, a series of circuit breakers capable of producing musical tones of different pitch, and a corresponding series of keys for throwing the circuit breakers into or out of operation, whereby several tones simultaneously may be transmitted through a single wire.

ELISHA GRAY.

Witnesses:

WM. J. PEYTON.

E. C. DAVIDSON.

2153

second, the tone given forth is that known as the "fundamental C," while one hundred and twenty-eight terminal secondary currents or impulses will be induced in the secondary circuit of the induction apparatus, and transmitted through the animal tissue above mentioned, forming part of said circuit, to the resonant receiver, and will, from some cause not understood or explicable in the present stage of the art, vibrate the same synchronously with the transmitting electrotome, and thus give forth a musical tone of the same pitch.

A metallic plate, stretched by metallic strings above a sounding-board—such, for instance, as the body of an ordinary violin—may be used with good effect to receive the vibrations, instead of the hollow cylinder above described.

From the foregoing description it will be seen that musical tones produced at the transmitting stations can simultaneously be produced at the receiving station, however distant. When two or more keys are simultaneously or successively depressed, corresponding tones will simultaneously be transmitted, thus producing harmony or melody.

The interruptions in the primary circuit which cause the induced secondary currents or impulses may be produced by a mechanical circuit-breaker having the requisite rapidity of motion, such as a revolving wheel or revolving brush; or they may be produced by providing the vibrating reed or reeds of an organ with contact points, so that, as the reed vibrates, it will transmit impulses corresponding in number per second to the number of vibrations per second of the notes sounded by the organ pipe.

I prefer to use the impules of the induced secondary currents as the transmitting medium, as such use affords the most convenient way of obtaining electricity of high tension, which is that best adapted for penetrating a slightly resisting medium, such as the animal tissue hereinbefore mentioned.

The secondary coil is not essential, as the secondary circuit induced in the primary coil may be utilized for transmitting the signals.

My improvement enables me to operate with a very slight amount of current, as the battery power required to produce and transmit the vibrations is less than one hundredth part of the battery power now required to transmit signals over long land lines.

My improved method can advantageously be substituted for the Morse telegraph alphabet now in general use, as an alphabet can

be constructed on the principle of using tones of different pitch for the different letters, which will admit of great rapidity of transmission.

By means of my improved apparatus, not only may a tune be transmitted by a single operator to a distant point, but the different parts of such tune simultaneously may be reproduced at a common point from different places, a separate part of the tune being played at each place.

The apparatus can also advantageously be employed in studying acoustics and the physical theory of music.

The combination, with a main line, of an intermittent circuit-breaker, or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for and controlling each such circuit-breaker, are not broadly claimed herein, as they constitute a part of the subject matter of another application for Letters Patent of the United States, filed by me February 23, 1875.

I claim as my invention:

1. The hereinbefore described art of transmitting musical impressions or sounds telegraphically by producing musical impressions or sounds at the transmitting end of a telegraphic circuit by causing interruptions in the electric currents of sufficient frequency to produce musical tones, transmitting said tones through an electric current composed in part of animal tissue, and reproducing them at the receiving end of the line by means of a resonant body, which is also a conductor of electricity, substantially set forth.

2. The electro-harmonic telegraph apparatus hereinbefore set forth, consisting of the combination of a telegraph circuit composed in part of animal tissue, a circuit breaker capable of producing a musical tone, and a resonant conductor of electricity capable of reproducing that tone at the receiving end of the circuit.

3. The combination, substantially as hereinbefore set forth, of a telegraphic circuit composed in part of animal tissue, a resonant receiver, which is also a conductor of electricity, a series of circuit breakers capable of producing musical tones of different pitch, and a corresponding series of keys for throwing the circuit breakers into or out of operation, whereby several tones simultaneously may be transmitted through a single wire.

ELISHA GRAY.

Witnesses:

WM. J. PEYTON.

E. C. DAVIDSON.

purpose. The local circuit passes through the analyzing spring and its contact points to the metal lever, and thence to the instrument and local battery. When the analyzing spring or reed is thrown into vibration the metal lever, having a rate of vibration less than that of the analyzing spring, is not able to follow its vibrations and thus preserve a continuous contact, as would be the case if its rate of vibration were as great or greater than that of the analyzing spring; but is made to jar or rattle at the point of contact, and for all practical purposes it opens the local circuit and holds it open so long as the analyzing spring continues to vibrate. When the vibration ceases the points come to rest and the circuit is re-established, operating a magnet in the ordinary way.

My present invention constitutes an improvement upon the receiver shown in the application above mentioned, and consists in an improved device for operating the local circuit.

In the accompanying drawings, which represent so much of my improved receiving apparatus as is necessary to illustrate the subject-matter herein claimed, Fig. 1 is a plan or top view; Fig. 2, a vertical transverse section there through on the line * * * of Fig. 1.

The battery wires are connected with binding posts or screws B B′, C C′, mounted, as usual, upon a baseboard, A. The receiving apparatus is mounted upon a triangular frame, D, of metal, suitably secured to this base by screws or other well-known means. An ordinary electro-magnet, E, is mounted upon this frame, with its poles at right angles to, but in the same horizontal plane as the vibrating tension bar or analyzing spring F, provided with suitable tension devices for regulating the pitch of the tone produced by its vibrations. A light metal elbow-lever, or circuit interrupter, G, rocks on pivots *g* in an insulated post, H, mounted on the metal frame D. The free end of this lever is provided with a platina contact point, resting on a corresponding point on the vibrating bar F. The elbow-lever is designed to vibrate at a slower rate than the analyzer spring. This rate of vibration is regulated by a small spiral spring, *i*, one end of which is attached to the elbow-lever and the other is connected by a cord to a windlass, or pins, I, turning in bearings in the post H. The main current enters the magnet through the wire M, and passes out through the wire M′. The local current consists of the wires L L′.

In the operation the impulses transmitted through the main line throw the receiver or analyzing spring into vibration, and as

the elbow-lever G vibrates more slowly, the circuit is practically kept open until closed by the key, as hereinbefore explained.

I claim:

The combination, substantially as hereinbefore set forth, of the vibrating receiving spring, the elbow-lever, circuit interrupter and mechanism, substantially such as described, for adjusting the rate of vibration of said lever.

In testimony whereof, I have hereunto subscribe my name.

ELISHA GRAY.

Witnesses:

WM. J. PEYTON.

E. C. DAVIDSON.

2159

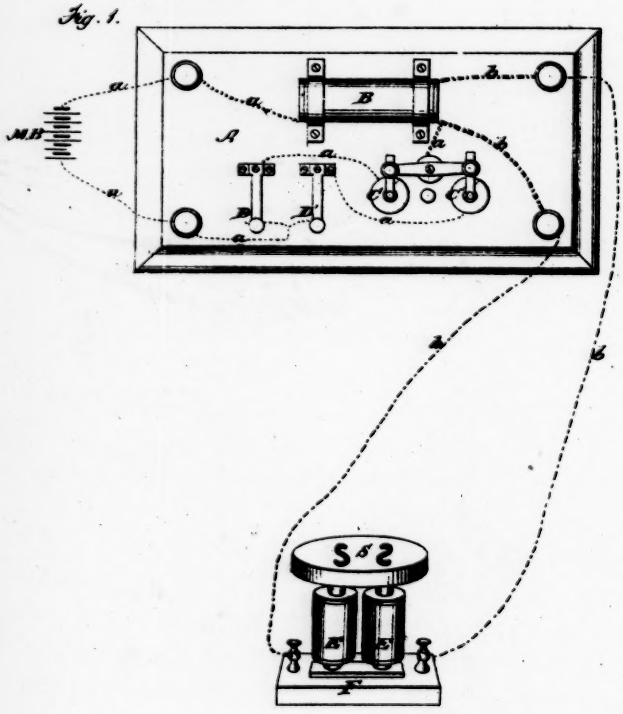
2 Sheets--Sheet 1.

E. GRAY.

Electric Telegraph for Transmitting Musical Tones.

No. 166,095. Patented July 27, 1875.

Fig. 1.



Witnesses.
C. F. Brown.
Ewell & Flint

Inventor.
Elisha Gray
by his attorney
A. L. Hayes

2160

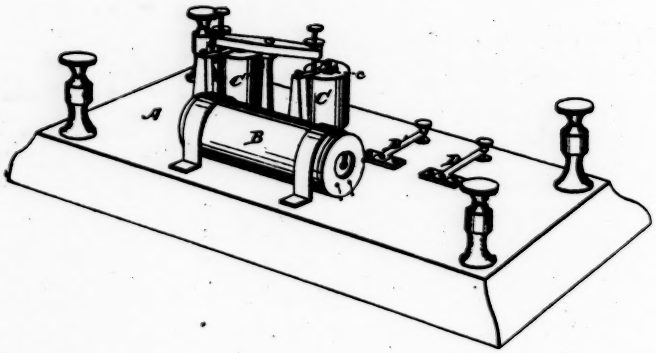
2 Sheets--Sheet 2.

E. GRAY.

Electric Telegraph for Transmitting Musical Tones.

No. 166,095. Patented July 27, 1875.

Fig. 2.



Witnesses.
C. F. Brown
Ewell A. Hick

Inventor.
Elisha Gray
by his attorney
A. L. Hayes

(No. 43.) Defendants' Exhibit, "Gray's Magnet Receiver Patent."

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 10.]

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN ELECTRIC TELEGRAPHS FOR TRANSMITTING MUSICAL TONES.

Specification forming part of Letters Patent No. 166,095, dated July 27, 1875; application filed January 19, 1875.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois, have invented a certain new and useful Apparatus for Transmitting Musical Impressions or Sounds Telegraphically, of which I hereby declare the following to be a full, clear, and exact description:

My invention relates to what I term an "electro-harmonic telegraph," and is based upon the fact well known to electricians that an electro-magnet elongates under the action of the electric current, and contracts again when the current ceases. Consequently, a succession of impulses or interruptions will cause the magnate to vibrate, and if these vibrations be of sufficient frequency a musical tone will be produced, the pitch of which will depend upon the rapidity of the vibrations.

I have discovered that by interrupting an electric current at the transmitting end of a line with sufficient frequency to produce a musical tone by an instrument vibrated by said interruptions, and transmitting the impulses thus induced to an electro-magnet at the receiving end of the line, the latter will vibrate synchronously with the transmitting instrument and thus produce a musical tone or

note of a corresponding pitch. The object of my invention is to utilize this discovery for the transmission of intelligible signals to a distance by electricity; to which end my improvement consists in the combination of a telegraphic circuit, a series of circuit breakers capable of producing musical tones of different pitch, a series of keys for simultaneously or successively throwing said circuit-breakers into or out of operation, and an electro-magnet receiver which is thrown into operation by the transmitter, whereby tones of different pitch may be reproduced at the receiving end of the line by the use of a single circuit.

In the accompanying drawings, Figure 1 shows a plan view of the transmitting part of my improved apparatus, the receiver appearing in perspective. Fig. 2 is a view, in perspective, of the transmitter.

The transmitting apparatus is mounted upon a base-board A, as usual. The induction coil B has the usual primary and secondary circuits. An ordinary automatic electrotome C has a circuit-closing spring *c*, so adjusted as, when in action, to produce a musical tone according to its length, thickness, and adjustment. A common telegraph key, D, is placed in the primary circuit to make or break the battery connection. In the drawings I have shown two electrotomes of identical construction, but of different pitch, and two keys, both the keys and electrotomes being placed in the primary circuit, which is so divided that part of the circuit passes through each key and its corresponding electrotome. The number of electrotomes may be increased, so that tomes extending through two or more octaves may be produced. An ordinary electro-magnet is provided at the receiving end of the line.

The operation of the apparatus is as follows: In the arrangement shown in the drawings when a key is closed the primary circuit will pass from the battery H through that key and its corresponding electrotome, and will be automatically interrupted in the usual manner. The spring of the electrotome will thus be caused to vibrate rapidly and to produce a tone, the pitch of which is determined by the rate of vibration. It is obvious that several keys may be depressed simultaneously. These vibrations or interruptions of the current will simultaneously produce in the secondary circuit of the induction coil a series of induced currents or impulses corresponding in number with the vibrations of the electrotome, and as the receiving electro-magnet is connected with this circuit it will be caused to vibrate, thus producing a tone of corresponding pitch,

the sound of which may be intensified by the use of a hollow cylinder, S, of metal, placed on the poles of the magnet.

When a single electrotome is thrown into action, its corresponding tone will be reproduced on the sounder by the magnet. When electrotomes of different pitch are successively operated their tones will be correspondingly reproduced by the receiver, and when two or more electrotomes are simultaneously sounded, the tone of each will still be reproduced without confusion on the sounder, by which means I am enabled to reproduce melodies or tunes.

Mechanical circuit breakers might be substituted for the automatic vibrating electrotome, hereinbefore described, and I have, in fact, used such mechanical circuit breakers of various construction, but I found the electrotome more satisfactory in practice.

In this instance the receiver is shown and described as operated by the induced current of the secondary coil; but the secondary or extra current of a primary coil, may be used instead thereof with good effect.

My apparatus is specially adapted to telegraphing on long land and submarine lines. By it letters and signals can be represented by tones differing in pitch; or the ordinary Morse signals can be made by short and long interruptions in a prolonged tone of the same pitch; thus securing great rapidity of transmission.

An application for Letters Patent of the United States, filed by me April 18, 1874, shows an apparatus somewhat similar to the one herein described, for transmitting musical tones through animal tissue to a resonant electrical receiver. I do not, therefore, claim herein anything therein shown. Neither do I claim herein the combination, with the main line, of an intermittent circuit-breaker, or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for and controlling each such circuit-breaker, as it constitutes the subject matter of another application filed by me February 23, 1875. The combination of a telegraphic circuit and automatic circuit-breaker capable of producing a musical tone, and an electromagnet receiver which produces the tone by being thrown into vibration by impulses generated by the circuit-breaker is not broadly claimed herein, as this combination constitutes a part of the subject matter of said application, also

I claim as my own invention—

The combination of a telegraphic circuit, a series of circuit-breakers capable of producing musical tones of different pitch, a

3164

series of keys for simultaneously or successively throwing said circuit-breakers into or out of operation, and an electro-magnet receiver, which is thrown into operation by the transmitters, whereby tones of different pitch may be reproduced at the receiving end of the line by the employment of a single circuit.

ELISHA GRAY.

Witnesses:

E. C. DAVIDSON,

WM. J. PEYTON.

(No. 43a.) Defendants' Exhibit, "Magnet Receiver Re-Issue, Art Division."

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 10.]

ELISHA GRAY, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE HARMONIC TELEGRAPH COMPANY, OF NEW YORK CITY.

IMPROVEMENT IN ART OF TRANSMITTING MUSICAL IMPRESSIONS OR SOUNDS TELEGRAPHICALLY.

Specification forming part of Letters Patent, No. 166,095, dated July 27, 1875: re-issue No. 8,558, dated January 28, 1879; application filed May 7, 1878.

DIVISION A.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook, and State of Illinois, have invented certain new and useful improvements in the art of transmitting musical impressions or sounds telegraphically, of which improvements I hereby declare the following to be a full, clear, and exact description.

My invention relates to what I term an "Electro Harmonic Telegraph," and is based upon the fact, well known to electricians, that an electro-magnet elongates under the action of an electric current, and contracts again when the current ceases; consequently a succession of impulses or interruptions will cause the magnet to vibrate, and if these vibrations be of sufficient frequency a musical tone will be produced, the pitch of which will depend upon the rapidity of the vibrations.

My improvements are based upon the discovery above mentioned.

The subject-matter claimed will hereinafter specifically be designated.

In the accompanying drawings Fig. 1 represents an arrangement upon circuit of apparatus which I use for the objects carrying out of my invention, the transmitting part of the apparatus, being shown in plan, and the receiver in perspective. Fig. 2 represents a view

in elevation of the transmitting apparatus. Fig. 3, an end view thereof, and Fig. 4, a detailed view of one of the rheotomes.

In the apparatus shown I make use of induced currents from either a primary or secondary coil for affecting the vibrating bar or core of an electro-magnet, and cause the necessary succession of said currents by interruption in the primary circuit made by an automatic or mechanical circuit-breaker.

The transmitting apparatus is mounted upon a suitable frame or base, A. An ordinary induction coil, B, has the usual primary and secondary circuits *a b*. Automatic vibrating electrotomes C C′, of the usual construction, have their vibrating circuit-closing springs C so adjusted that when in action they produce musical tones which, from the difference in adjustment and the length and thickness of the springs, are of different pitch. A common telegraph key, D, is placed in the primary circuit to make or break the battery-connections.

In the drawings I have shown two electrotomes of identical construction, but of different pitch and two keys. Both the keys and electrotomes are in the primary circuit, which is so divided that part of the circuit passes through each key and its corresponding electrotome. The number of electrotomes may be increased, so that tones extending through two or more octaves may be produced.

At the receiving-station an electro-magnet, E, or a coil of wire surrounding a bar of iron, is placed in circuit. A hollow box, drum, cylinder, or resonator, S, of metal, is placed on the poles of the magnet. This resonator, it will be observed, is composed of a circumferential band, having two end walls, disks or diaphragms, one of which rests upon the magnets, constituting an armature therefor, and vibrating in unison therewith, while the other is perforated with S-shaped openings, something like the sounding-board of a violin, thus constituting what I call a "common-receiver"—that is, one capable of responding to or reproducing all kinds of tones.

The operation of the apparatus is as follows: Under the arrangement shown in the drawings when the key is closed the primary circuit will pass from the battery, M B, through the wires *a*, the key, and its corresponding electrotome, and will be automatically interrupted in the usual manner. The spring of the electrotome will thus be caused to vibrate rapidly and to produce a tone, the pitch of which is determined by the rate of vibration.

It is obvious that several keys may be closed or depressed simultaneously.

The rhythmical impulses, vibrations, or interruptions of the current representing the tones will simultaneously produce in a secondary circuit *b*, of the induction coil, a series of induced currents, impulses or vibrations, corresponding in number with the vibrations of the electrotomes, and as the receiving electro-magnets, E, is connected with this current it will be caused to vibrate correspondingly, thus producing a tone or tones of corresponding pitch with those received from the transmitting apparatus.

These tones are audibly reproduced and their sound intensified by the use of the hollow box, cylinder, sound intensifying chamber, or resonator, S, above mentioned.

The circuit may obviously be extended to any distance desired from the transmitting station.

When a single electrotome is thrown into vibration its corresponding tone will be reproduced on the sounder or resonator, S, by the magnet. When electrotomes of different pitch are successfully operated, their tones will be correspondingly reproduced by the receiver or resonator; and when two or more electrotomes are simultaneously sounded the tone of each will still be reproduced without confusion on the sounder or resonator, by which means I am enabled to reproduce composite tones, melodies, or tunes.

Mechanical circuit-breakers may be substituted for the automatically vibrating electrotomes hereinbefore described. I have, in fact, used such mechanical circuit-breakers of various construction; but I have found the electrotome more satisfactory in practice.

In this instance the receiver is shown and described as operated by the induced current of the secondary coil; but the secondary or extra current of the primary coil may be used instead thereof with good effect.

The above described apparatus is especially adapted to telegraph on long land and submarine lines. By it letters and signals can be represented by tones differing in pitch; or the ordinary Morse signals can be made by short and long interruptions in the prolonged tone of the same pitch, thus insuring great rapidity of transmission.

I do not claim herein the apparatus itself, as that forms the subject-matter of another division of this application filed simultaneously herewith.

Letters Patent of the United States No. 166,096, granted to me July 27, 1875, on an application originally filed April 18, 1874, show

an apparatus somewhat similar to the one herein described for transmitting musical tones through an electric circuit composed in part of animal tissue, and a resonant metallic receiver, but without the intervention of a magnet. I do not, therefore, claim herein anything shown in said patent. Neither do I claim herein the combination, with a main line, of an intermittent circuit-breaker, or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for and controlling each of said circuit-breakers, as such combination constitutes the subject matter of another application for Letters Patent of the United States, filed by me February 23, 1875.

The combination of a telegraphic circuit, an automatic circuit-breaker capable of producing a musical tone, and an electro-magnet receiver for reproducing the tone by being thrown into vibrations by impulses generated by the circuit-breaker is not broadly claimed herein, as this combination constitutes a part of the subject matter of my said application also; but neither of the said applications above mentioned show a disk or diaphragm of metal, or a sound-intensifying chamber or resonator in combination with a magnet.

I claim as of my own invention:

1. The hereinbefore described novel art, method or system of audibly and simultaneously reproducing upon the metal disk or diaphragm of the receiver (through the intervention of the electro-magnet included in the electric circuit), two or more series of rhythmical impulses or vibrations representing musical impressions, or sounds, or composite tones.

2. The hereinbefore described novel art, method, or system of intensifying in the resonator composite tones produced by the conjoint operation of the electro-magnet included in the electric circuit, and the disk or diaphragm of metal vibrating in unison therewith.

3. The hereinbefore described novel art, method or system of simultaneously transmitting two or more series of rhythmical impulses or vibrations representing composite tones through the electric circuit, and reproducing them through the intervention of the magnet, and the disk or diaphragm of metal vibrating in unison therewith at the receiving end of the line.

4. The hereinbefore described novel art, method or system of simultaneously reproducing in the electric circuit two or more series of rhythmical impulses or vibrations representing musical impressions or sound, or composite tones by the conjoint operation

2169

of the disk or diaphragm of metal, vibrated in unison with the electro magnet by induced currents of electricity.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

A. G. SWARTWOUT,

D. M. ERSKINE, JR.

(No. 43b.) "Defendants' Exhibit, Magnet-Receiver Re-issue. Apparatus Division."

J. A. W., Ex'r.

[Introduced in Record, p. 10.]

ELISHA GRAY, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE HARMONIC TELEGRAPH COMPANY, OF NEW YORK CITY.

IMPROVEMENT IN APPARATUS FOR TRANSMITTING MUSICAL IMPRESSIONS OR SOUNDS TELEGRAPHICALLY.

Specification forming part of Letters Patent No. 166,095, dated July 27, 1875; Re-issue No. 8559, dated January 28, 1879; application filed May 7, 1878.

DIVISION B.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois, have invented certain new and useful apparatus for transmitting musical impressions or sounds telegraphically, of which I hereby declare the following to be a full, clear and exact description.

My invention relates to what I term an "electro-harmonic telegraph," and is based upon the fact, well known to electricians, that an electro-magnet elongated under the action of an electric current and contracts again when the current ceases; consequently a succession of impulses or interruptions will cause the magnet to vibrate, and if these vibrations be of sufficient frequency a musical tone will be produced, the pitch of which will depend upon the rapidity of the vibrations.

The object of my present invention is to utilize this discovery for the transmission of intelligible signals to a distance by electricity, which ends I attain, first, by employing a diaphragm or disk of metal (capable of responding to all kinds of tones), vibrating in unison with an electro-magnet included in an electric circuit, to reproduce audibly rhythmical impulses or vibrations representing musical impressions or sounds, or tones transmitted through said circuit; second, by employing a sound-intensifying chamber or re-

sonator, having a disk or diaphragm responsive to rhythmical impulses or vibrations representing musical impressions or sounds, whereby said rhythmical impulses or vibrations are intensified and rendered audible; third, by combining an electric circuit, a sound-intensifying chamber or resonator, and a metal disk or diaphragm, acted upon through the intervention of an electro-magnet included in the circuit, to intensify and render audible rhythmical impulses or vibrations representing musical impressions or sounds produced in said magnet; fourth, by employing induced currents to reproduce upon a disk or diaphragm of metal (through the intervention of a magnet) rhythmical vibrations representing musical impressions or sounds; fifth, by employing a transmitter consisting of a coil or helix inducing rhythmical electric impulses or vibrations in an electric circuit without interrupting its continuity, and a receiver consisting of an electro-magnet having a metal disk or diaphragm for its armature; sixth, by combining a telegraphic circuit, a series of circuit-breakers capable of reproducing musical notes of different pitch, a series of keys for throwing said circuit-breakers into or out of operation, and an electro-magnet receiver vibrated by the transmitters.

In the accompanying drawings, Figure 1 represents an arrangement upon circuit of apparatus which I use for carrying out the objects of my invention, the transmitting part of the apparatus being shown in plan and the receiver in perspective; and Fig. 2 represents a view in elevation of the transmitting apparatus; Fig. 3, an end view thereof, and Fig. 4 a detailed view of one of the rhootomes.

In the apparatus shown I make use of induced currents from either a primary or secondary coil for affecting the vibrating bar or core of an electro-magnet, and cause the necessary succession of said currents by interruption in the primary circuit made by an automatic or mechanical circuit-breaker.

The transmitting apparatus is mounted upon a suitable frame or base, A. An ordinary induction coil B has the usual primary and secondary circuits *a b*. Automatic vibrating electrotomes C C^1, of the usual construction, have their vibrating circuit-closing springs *c* so adjusted that when in action they produce musical tones, which, from the difference in adjustment and the length and thickness of the springs, are of different pitch. A common telegraph key D, is placed in the primary circuit, to make or break the battery connection.

In the drawings I have shown two electrotomes of identical construction, but of different pitch, and two keys. Both the keys and electrotomes are in the primary circuit, which is so divided that part of the circuit passes through each key and its corresponding electrotome. The number of electrotomes may be increased so that tones extending through two or more octaves may be produced.

At the receiving station an electro-magnet E is placed in circuit. A hollow box, drum, cylinder or resonator S, of metal, is placed on the poles of the magnet. This resonator, will be observed, is composed of a circumferential band, having two end walls, disks or diaphragms, one of which rests upon the magnets, constituting an armature therefor, and vibrating in unison therewith, while the other is perforated with S-shaped openings somewhat like the sounding board of a violin, thus constituting what I call a "common receiver"—that is, one capable of responding to or reproducing tones of all kinds.

The operation of the apparatus is as follows: Under the arrangement shown in the drawings, when a key is closed, the primary circuit will pass from the battery M B, through the wires *a*, the key and its corresponding electrotome, and will be automatically interrupted in the usual manner. The spring of the electrotome will be caused to vibrate rapidily and to produce a tone the pitch of which is determined by the rate of vibration. It is obvious that several keys may be closed or depressed simultaneously. The rhythmical impulses, vibrations or interruptions of the current representing the tones will simultaneously produce in the secondary circuit *b* of the induction coil, a series of induced currents, impulses or vibrations, corresponding in number with the vibrations of the electrotome; and, as the receiving electro-magnet E is connected with this curcuit, it will be caused to vibrate correspondingly, thus producing a tone or tones of corresponding pitch with those received from the transmitting apparatus. These tones are audibly reproduced and their sound intensified by the use of the hollow box, cylinder, sound intensifying chamber or resonator above mentioned. The circuit may obviously be extended to any distance desired from the transmitting station.

When a single electrotome is thrown into vibration, its corresponding tone will be reproduced on the sounder or resonator S by the magnet. When electrotomes of different pitch are successively operated their tones will be correspondingly reproduced by the receiver, and when two or more electrotomes are simultaneously

sounded the tone of each will still be reproduced without confusion in the sounder or resonator S, by which means I am enabled to reproduce composite tones, melodies or tunes.

Mechanical circuit-breakers may be substituted for the automatically vibrating electrotomes hereinbefore described. I have, in fact, used such mechanical circuit-breakers of various construction, but I have found the electrotome more satisfactory in practice. In this instance the receiver is shown and described as operated by the induced current of the secondary coil, but the secondary or extra current of the primary coil may be used instead thereof with good effect.

The above described apparatus is especially adapted to telegraph on long land and submarine lines. By it letters and signals can be represented by tones differing in pitch; or the ordinary Morse signals can be made by short and long interruptions in a prolonged tone of the same pitch thus insuring great rapidity of transmission.

I do not broadly claim herein an art, method, or system of transmitting musical impressions or sounds telegraphically, as that constitutes the subject-matter of another division of this application filed herewith.

Letters Patent of the United States No. 166,096, granted to me July 27, 1875 (on an application originally filed April 18, 1874), show an apparatus somewhat similar to the one herein described, for transmitting musical tones through an electric circuit composed, in part, of animal issue and a resonant metallic receiver, but without the intervention of a magnet. I do not, therefore, claim herein anything shown in said application. Neither do I claim herein the combination, with a main line, of an intermittent circuit-breaker or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for, and controlling each of, said circuit-breakers, as such combination constitutes the subject-matter of another application for letters patent of the United States, filed by me February 23, 1875.

The combination of a telegraph circuit, an automatic circuit-breaker capable of producing a musical tone, and an electro-magnet receiver for reproducing the tone by being thrown into vibrations by impulses generated by the circuit-breaker is not broadly claimed herein, as this combination constitutes a part of the subject-matter of my said application also.

But neither of the said applications above mentioned shows a

diaphragm or a sound intensifying chamber or resonator in combination with a magnet.

I claim as of my own invention:

1. The diaphragm or disk of metal, capable of responding to all kinds of tones, vibrating in unison with the electro magnet included in the electric circuit, substantially as set forth.

2. The sound intensifying chamber or resonator, having a disk or diaphragm of metal, responsive to rhythmical responses or vibrations representing musical impressions or sounds produced in the electric circuit through the intervention of the electro-magnet, substantially as set forth.

3. In combination, the electric circuit, the sound intensifying chamber or resonator, the diaphragm or disk of metal, and the electro-magnet, the two latter vibrating responsively to rhythmical impulses or vibrations representing musical impressions or sounds transmitted through said circuit, substantially as set forth.

4. In combination, the primary circuit, the seconday circuit, the electro-magnet, and the disk or diaphragm of metal, responsively vibrated by induced currents of electricity to reproduce rhythmical impulses or vibrations representing musical impressions or sounds, substantially as set forth.

5. In combination, the transmitter consisting of a coil or helix, whereby rhythmical electrical impulses or vibrations may be induced in the telegraphic circuit without interrupting the continuity of the same, and the receiver consisting of the electro-magnet, having the metal disk or diaphragm for its armature, these being arranged to vibrate in unison with each other, and with the impulses or vibrations proceeding from the transmitting or inducing coil, substantially as set forth.

6. In combination, a telegraphic circuit, a series of circuit-breakers, capable of producing musical tones of different pitch, a series of keys for throwing said circuit-breakers into or out of operation, and an electro-magnet receiver which is thrown into vibration by the transmitters, whereby tones of different pitch may be reproduced at the receiving end of the line by the employment of a single circuit, substantially as set forth.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

A. G. SWARTWOUT,

D. M. ERSKINE, JR.

diaphragm or a sound intensifying chamber or resonator in combination with a magnet.

I claim as of my own invention:

1. The diaphragm or disk of metal, capable of responding to all kinds of tones, vibrating in unison with the electro magnet included in the electric circuit, substantially as set forth.

2. The sound intensifying chamber or resonator, having a disk or diaphragm of metal, responsive to rhythmical responses or vibrations representing musical impressions or sounds produced in the electric circuit through the intervention of the electro-magnet, substantially as set forth.

3. In combination, the electric circuit, the sound intensifying chamber or resonator, the diaphragm or disk of metal, and the electro-magnet, the two latter vibrating responsively to rhythmical impulses or vibrations representing musical impressions or sounds transmitted through said circuit, substantially as set forth.

4. In combination, the primary circuit, the seconday circuit, the electro-magnet, and the disk or diaphragm of metal, responsively vibrated by induced currents of electricity to reproduce rhythmical impulses or vibrations representing musical impressions or sounds, substantially as set forth.

5. In combination, the transmitter consisting of a coil or helix, whereby rhythmical electrical impulses or vibrations may be induced in the telegraphic circuit without interrupting the continuity of the same, and the receiver consisting of the electro-magnet, having the metal disk or diaphragm for its armature, these being arranged to vibrate in unison with each other, and with the impulses or vibrations proceeding from the transmitting or inducing coil, substantially as set forth.

6. In combination, a telegraphic circuit, a series of circuit-breakers, capable of producing musical tones of different pitch, a series of keys for throwing said circuit-breakers into or out of operation, and an electro-magnet receiver which is thrown into vibration by the transmitters, whereby tones of different pitch may be reproduced at the receiving end of the line by the employment of a single circuit, substantially as set forth.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

A. G. SWARTWOUT,

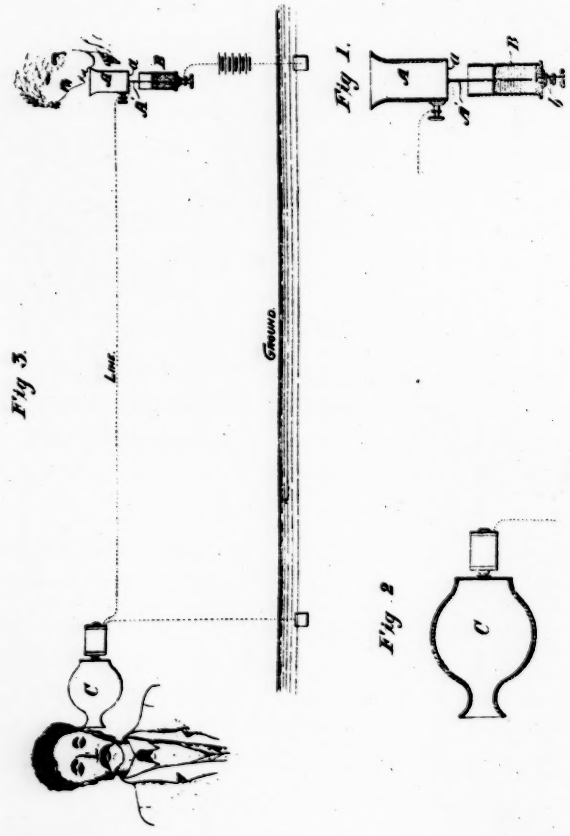
D. M. ERSKINE, JR.

21115

ELISHA GRAY

INSTRUMENTS FOR TRANSMITTING AND RECEIVING . VOCAL SOUNDS TELEGRAPHICALLY.

CAVEAT FILED FEBRUARY 14TH 1876.



WITNESSES

Wm A Skinner
F. Smith

INVENTOR

Elisha Gray

(No. 44.) Defendants' Exhibit, "Gray's Caveat 2."

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 11.]

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, Greeting:

This is to certify that the annexed is a true copy from files of this office of the Caveat of Elisha Gray, filed Feb. 14, 1876, for "Art of Transmitting Vocal Sounds Telegraphically."

In testimony whereof, I, W. H. Doolittle, acting Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this twenty-eighth day of March, in the year of our Lord one thousand eight hundred and seventy-eight, and of the Independence of the United States the one hundred and second.

[SEAL]

W. H. DOOLITTLE,
Acting Commissioner.

ELISHA GRAY.

UNITED STATES PATENT OFFICE.

SPECIFICATION.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois, have invented a new art of transmitting vocal sounds telegraphically, of which the following is a specification.

It is the object of my invention to transmit the tones of the human voice through a telegraphic circuit, and reproduce them at the receiving end of the line, so that actual conversations can be carried on by persons at long distances apart.

I have invented and patented methods of transmitting musical impressions or sounds telegraphically, and my present invention is based upon the modification of the principle of said invention, which is set forth and described in letters patent of the United States, granted to me July 27, 1875, respectively numbered 166,095 and 166,096, and also in an application for letters patent of the United States, filed by me February 23, 1875.

To attain the objects of my invention, I devised an instrument capable of vibrating responsively to all the tones of the human voice, and by which they are rendered audible.

In the accompanying drawings I have shown an apparatus embodying my improvements in the best way now known to me, but I contemplate various other applications, and also changes in the details of construction of the apparatus, some of which would obviously suggest themselves to a skillful electrician, or a person versed in the science of acoustics, on seeing this application.

Figure 1 represents a vertical central section through the transmitting instrument.

Fig. 2. A similar section through the receiver; and

Fig. 3. A diagram representing the whole apparatus.

My present belief is, that the most effective method of providing an apparatus capable of responding to the various tones of the human voice, is a tympanum, drum or diaphragm, stretched across one end of the chamber, carrying an apparatus for producing fluctuations in the potential of the electric current, and consequently varying in its power.

In the drawings, the person transmitting sounds, is shown as talking into a box, or chamber, A, across the outer end of which is stretched a diaphragm *a*, of some thin substance, such as parchment or gold beater's skin, capable of responding to all the vibrations of the human voice, whether simple or complex. Attached to this diaphgram is a light metal rod A′, or other suitable conductor of electricity, which extends into a vessel B made of glass or other insulating material, having its lower end closed by a plug, which may be of metal, or through which passes a conductor *b*, forming part of the circuit. This vessel is filled with some liquid possessing high resistance, such, for instance, as water, so that the vibrations of the plunger or rod A′ which does not quite touch the conductor *b*, will cause variations in resistance and consequently, in the potential of the current passing through the rod A′.

Owing to this construction, the resistance varies constantly, in

response to the vibrations of the diaphragm, which although irregular, not only in their amplitude, but in rapidity, are nevertheless transmitted, and can, consequently, be transmitted through a single rod, which could not be done with a positive make and break of the circuit employed, or where contact points are used.

I contemplate, however, the use of a series of diaphragms in a common vocalizing chamber, each diaphragm carrying an independent rod, and responding to a vibration of different rapidity and intensity, in which case, contact points mounted on other diaphragms may be employed.

The vibrations thus imparted are transmitted through an electric circuit to the receiving station, in which circuit is included an electro-magnet of ordinary construction, acting upon a diaphragm to which is attached a piece of soft iron, and which diaphragm is stretched across a receiving vocalizing chamber *c*, somewhat similar to the corresponding vocalizing chamber A.

The diaphragm at the receiving end of the line is thus thrown into vibration corresponding with those at the transmitting end, and audible sounds or words are produced.

The obvious practical application of my improvement will be to enable persons at a distance to converse with each other through a telegraphic circuit, just as they now do in each other's presence, or through a speaking-tube.

I claim as my invention, the art of transmitting vocal sounds or conversations telegraphically through an electric circuit.

ELISHA GRAY.

Witnesses:

WM. J. PEYTON,
WM. D. BALDWIN.

STATE OF
County of } ss:
District of Columbia,

ELISHA GRAY, the within named petitioner, being duly sworn, doth depose and say, that he verily believes himself to be the original and first inventor of the Art of Transmitting Vocal Sounds described in the foregoing specification; that he does not know or believe that

2119

the same was ever before known or used; and that he is a citizen of the United States.

ELISHA GRAY.

Subscribed and sworn to before me this 14th day of February, A. D. 1876.

[SEAL.] JOHN T ARMS,
Notary Public.

To the Commissioner of Patents:

The petition of Elisha Gray, of Chicago, in the County of Cook in the State of Illinois, respectfully represents, that he has made certain improvements in the Art of Transmitting Vocal Sounds telegraphically, and that he is now engaged in making experiments for the purpose of perfecting the same, preparatory to applying for letters patent therefor.

He therefore prays that the subjoined description of his invention may be filed as a caveat in the confidential archives of the Patent Office.

ELISHA GRAY.

Patent Office,
Feb. 14, 1876.
U. S. A.

(Official Stamp.)

Copy sent Feb. 19, S. R. A.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb'y 19, 1876.

SIR—You are hereby notified that application has been made to this office for letters patent for Telephonic Telegraph, &c., with which the invention described in your caveat, filed on the 14th day of February, 1876, apparently interferes, and that said application has been deposited in the confidential archives of the office under

provision of Section 4902 of the Revised Statutes of the United States, which section reads as follows:

SECTION 4902. Any citizen of the United States who makes any new invention or discovery, and desires further time to mature the same, may, on payment of the fees required by law, file in the Patent Office a caveat, setting forth the design thereof, and of its distinguishing characteristics, and praying protection of his right until he shall have matured his invention. Such caveat shall be filed in the confidential archives of the office and preserved in secrecy, and shall be operative for the term of one year from the filing thereof, and if application is made within the year by any other person for a patent with which such caveat would in any manner interfere, the Commissiener shall deposit the description, specification, drawings and model of such application in like manner in the confidential archives of the office, and give notice thereof, by mail, to the person by whom the caveat was filed. If such person desires to avail himself of his caveat he shall file his description, specification, drawings and model within three months from the time of placing the notice in the post office in Washington, with the usual time required for transmitting it to the caveator added thereto; which time shall be endorsed on the notice. An alien shall have the privilege herein granted if he has resided in the United States next preceding the filing of his caveat, and has made oath of his intention to become a citizen.

If you would avail yourself of your caveat it will be necessary for you to file a complete application within three months from date, three days additional, however, being allowed for the transmission of this notice to your place of residence.

Very respectfully,

R. H. DUELL,
Commissioner.

ELISHA GRAY,
Care W. D. Baldwin,
Present.

EXAMINER'S ROOM No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb. 19, 1876.

E. GRAY,
Care W. D. Baldwin:

In relation to the foregoing notice in relation to your caveat it may be well to add that the matters in the App'n referred to seem to conflict with your caveat in these particulars, viz.:

1st. The receiver set into vibration by undulatory currents.

2d. The method of producing the undulations by varying the resistance of the circuit.

3d. The method of transmitting vocal sounds telegraphically by causing these undulatory currents, &c.

Z. F. WILBUR,
Examiner.

Copy sent
Feb. 25.
S. R. A.

EXAMINER'S ROOM No. 118,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Feb. 25, 1876.

E. GRAY,
Care W. D. Baldwin, Present:

Caveat for Art of Transmitting Vocal Sounds Telegraphically.
Feb. 14, 1876.

The notice to complete having been given under a misapprehension of the rights of the parties, is hereby withdrawn.

Z. F. WILBER,
Examiner.

$10 Mail.

MEMORANDUM OF FEE PAID AT U. S. PATENT OFFICE.

Paper will be filed to-day.
Inventor,
E. GRAY.

CAVEAT.

Invention.
Transmitting Vocal Sounds Telegraphically.
Date of Payment,
Feby. 14, 1876.
Fee,
$10.
Solicitor,
Wm. D. Baldwin.
Patent Office,
Feb. 14, 1876.
U. S. A.
(Official Stamp.)

1876.

No. CAVEAT. Wilbur, 48.

ELISHA GRAY,
Of Chicago, County of Cook, State of Illinois.

Art of Transmitting Vocal Sounds Telegraphically.

Rec'd,	Feb. 14, 1876.
Petition,	" " "
Affidavit,	" " "
Specification,	" " "
Drawing within,	" " "
Model,	" " "
Cert. dep.	" " "
1 cash, $10,	Feb. 14, 1876.
Circular,	" " "
2.	" " "
3.	" " "

W. D. BALDWIN,
Present.

1. Letter to Caveator, Feby. 19, 1876. (Notice to complete.)
2. Letter, Feby. 25, 1876.

Simmons
vs.

158 | S. X.

58

2183

Copy sent
Sept. 20, 1877,
M. E. S.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Sept. 20th, 1877.

ELISHA GRAY,

Care Baldwin, Hopkins & Peyton, Present:

SIR: You are hereby notified, that application has been made to this office for Letters Patent for Speaking Telegraph, involving the use of a series of diaphragms in a common vocalizing chamber, with which the invention described in your caveat, filed on the 14th day of February, 1876, renewed February 14th, 1877, apparently interferes, and that said application has been deposited in the confidential archives of the office, under provisions of Section 4902 of the Revised Statutes of the United States, which section reads as follows:

SEC. 4902. Any citizen of the United States who makes any new invention or discovery, and desires further time to mature the same, may, on payment of the fees required by law, file in the Patent Office, a caveat, setting forth the design thereof, and of its distinguishing characteristics, and praying protection of his right until he shall have matured his invention. Such caveat shall be filed in the confidential archives of the office and preserved in secrecy, and snall be operative for the term of one year from the filing thereof; and if application is made within the year by any other person for a patent with which such caveat would in any manner interfere, the Commissioner shall deposit the description, specification, drawings and model of such application in like manner in the confidential archives of the office, and give notice thereof by mail, to the person by whom the caveat was filed. If such person desires to avail himself of his caveat, he shall file his description, specification, drawings and model within three months from the time of placing the notice in the post office in Washington, with the usual time required for transmitting it to the caveator added thereto, which time shall be endorsed on the notice. An alien shall have the privilege herein granted, if he has resided in the United States one year next preceding the filing of his caveat, and has made oath of his intention to become a citizen.

If you would avail yourself of your caveat, it will be necessary for you to file a complete application within three months from date, three days additional, however, being allowed for the transmission of this notice to your place of residence.

Very respectfully,

ELLIS SPEER,
Commissioner of Patents.

MEMORANDUM OF FEE PAID AT U. S. PATENT OFFICE.

2184

108

Inventor.

$10.

ELISHA GRAY,
Renewal of Caveat.
Filed Feb. 14. 1876.

Invention,
Telegraphy.
Date of Payment.
Feb. 14, 1877.
Fee,
$10.

WM. D. BALDWIN,
Solicitor.
Present.

Patent Office,
Feb. 14, 1877.
U. S. A.
[Official Stamp.]

1877.

48 WILBUR.

23

1st. Renewal of Caveat of Feb. 14, 1876.
No.

ELISHA GRAY,
Of Chicago, County of Cook, State of Illinois.
Art of Transmitting Vocal Sounds Telegraphically.
Telelogue.

Recd.	Feb. 14, 1877.		
Petition,	"	"	"
Affidavit,	"	"	"
Specification,	"	"	"
Drawing,	"	"	"
Model,	"	"	"
Cert. dep.,	"	"	"

7185

1. Cash $10, Feb. 14, 1877.
2. Circular, " " "
3.

WM. D. BALDWIN,
Present.

Notice to Caveator,
Sept. 20, 1877.

AMERICAN BELL TELEPHONE COMPANY, - 13

2186

2 Sheets—Sheet 1.

E. GRAY.

TELEPHONIC TELEGRAPH APPARATUS.

No. 175,971. Patented April 11, 1876.

Fig 1

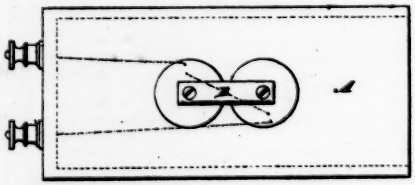
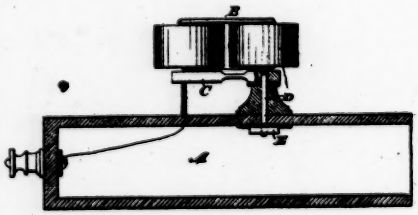


Fig 2.



WITNESSES

Wm Achmidt
F. Smith

By his Attorney

INVENTOR

Elisha Gray.
Wm Baldwin

2187

2 Sheets—Sheet 2.

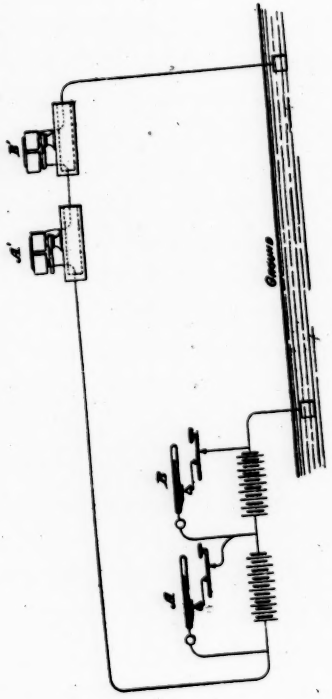
E. GRAY.

TELEPHONIC TELEGRAPH APPARATUS.

Patented April 11, 1876.

No. 175,971.

Fig 3.



WITNESSES

Wm A Skinkle

Walter De Long

By his Attorney

INVENTOR

Elisha Gray

W. D. Baldwin

3188

(No. 45.) Defendants' Exhibit, "Gray Sounding Box Receiver Patent."

J. A. W., Ex'r.

[Introduced in Record, p. 11.]

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN TELEPHONIC TELEGRAPH APPARATUS.

Specification forming part of the Letters Patent No. 175,971, dated April 11th, 1876. Application filed January 8th, 1876.

To all whom it may concern:

Be it known, that I, ELISHA GRAY, of Chicago, in the County of Cook and State of Illinois, have invented certain new and useful improvements in the Art of Transmitting Musical Sounds Telegraphically, as well as certain new and useful improvements on apparatus for so transmitting such sounds, of which art and apparatus the following is a specification:

My invention relates to electro-harmonic telegraphs of the class shown and described in Letters Patent of the United States, granted to me July 27th, 1875, and respectively numbered 166,095 and 166,096, and in an application for Letters Patent filed by me February 23, 1875.

The object of my invention is to dispense with local batteries and sounders, and all adjustment at the receiving end of the line, which end I attain by means of an apparatus which analyzes composite tones transmitted electrically through a wire, whereby the operator is enabled to read directly from the tone transmitted.

The subject-matter claimed hereinafter specifically will be designated.

In the accompanying drawings, which show so much of my improved apparatus as is necessary to illustrate the invention herein claimed, Fig. 1 is a plan or top view and Fig. 2 a side elevation, partly in section, of one of my improved sounders or receivers. Fig. 3 is a diagram showing my improved transmitting and receiving apparatus as adapted to the transmission of several tones simultaneously.

A resonant box, A, such as used for intensifying the sound of tuning forks, is shown as closed at one end. A screw bolt, D, or other suitable support secured upon this box, sustains an electromagnet, B, of well-known construction. A vibrating tongue or reed,

C, of steel is so fastened upon the support D, and is united in one pole of the magnet B. The free end of the reed passes close to, but does not touch, the other pole of the magnet.

For convenience of removal or replacement, all the parts of the apparatus may be united by means of a common bolt and nut, E.

The box is tuned to produce a maximum resonance of the desired tone, and the reed is accurately tuned correspondingly. Consequently, as the reed vibrates, the sound of its fundamental tone is intensified by the resonance of the box in accordance with well-known laws of acoustics.

If, now, the electro-magnet be connected in a telegraphic circuit in the same way as one of my analyzers described in the application aforesaid, and the note be transmitted by means of one of my transmitters described in said application for Letters Patent, the note will sound in the box, provided the tone transmitted corresponds with that of the box, otherwise the note will not be heard. Should a second analyzer be similarly placed in the circuit and tuned to a different pitch and a second note of corresponding pitch be transmitted, it will sound in the box of corresponding pitch without effecting the other. The same rule holds with a larger number.

I have in practice thus analyzed and reproduced as many as eight different tones simultaneously transmitted through a single wire, and, as I have demonstrated, by using the Morse signals, eight messages can simultaneously be sent over each wire as rapidly as each operator can transmit with the common telegraphic key, the advantages of my invention are obvious.

I believe it, however, to be practicable simultaneously to transmit a number of messages even greater than that above mentioned.

The reed C is made of a steel bar with parallel sides, the tuning being done by cutting away the sides near the fixed ends, as shown in the drawings. I find this construction in practice, to obviate the tendency of the reeds to break into notes, or to respond to notes other than their own, as has been the tendency of other forms of reeds tried by me.

I claim as my invention—

1. The hereinbefore described art of transmitting musical sounds telegraphically by reproducing such sounds at the receiving end of the line by means of a vibrating reed and a sounding box of corresponding pitch.

7190

2. The combination substantially, as hereinbefore set forth of an electro-magnet, a vibrating reed and a sounding box of corresponding pitch, united at the receiving end of an electric circuit.

3. The combination, substantially as hereinbefore set forth, with an electric circuit, of a series of electro-magnets, a series of vibrating reeds, producing musical tones of different pitch, and a series of correspondingly tuned sounding boxes, whereby each box is caused to sound its own note while rejecting all others.

4. The vibrating reed, constructed as hereinbefore set forth, with parallel sides, and with recesses near its fixed end, whereby its tendency to vibrate in unison with tones other than its own is prevented.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

ENOS M. BARTON,

GEO. A. BLISS.

2191

(No. 46.) Defendants' Exhibit, "Gray's Closed Circuit Patent."

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 11.]

ELISHA GRAY, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE HARMONIC TELEGRAPH COMPANY OF NEW YORK CITY.

IMPROVEMENT IN ELECTRO-HARMONIC TELEGRAPHS.

Specification forming part of Letters Patent, No. 186,340, dated January 16, 1877; application filed January 27, 1876.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois, have invented a new and useful improvement in the art of transmitting and analyzing musical impressions or sounds and in apparatus for so transmitting and analyzing such sounds, of which the following is a specification.

My invention more especially relates to an electro-harmonic system of multiple telegraphy heretofore invented by me, and secured by sundry Letters Patent of the United States, in which composite musical tones are transmitted through a single wire, and analyzed or separated at the receiving end of the line by vibrating reeds, bars or strings tuned correspondingly with the respective transmitters of the composite tones.

In an application for Letters Patent of the United States, filed by me February 23, 1875, for transmitting musical vibrations by electricity, I have shown not only the various devices for transmitting or receiving the musical impressions, but also one method of arranging the electric circuit for producing the desired result, including the relation of the main battery to the line and instruments at both ends, and describe the effects produced.

In my prior patents and application, above mentioned, the full force of the battery was at all times exerted upon the line; that is to say, when one transmitter was employed and the others were at rest, it worked with the full force of the whole main battery, and when all the transmitters were employed, the same force was necessarily divided among them; consequently the amplitude of the vi-

brations of any given tone would diminish or increase, according to the number of tones simultaneously sent to line, thus rendering analysis at the receiving end of the line more difficult.

My present improvement contemplates the avoidance of this objection, by insuring the transmission of tones of uniform amplitude, of wave, whether a greater or less number of tones be transmitted simultaneously, which end I attain by combining each transmitter with its respective section of the main battery, by a short or shunt circuit, in such manner that each section is utilized for the transmission of the vibrations for its own tone, without interfering or drawing upon the other section of the battery, or opening the main circuit, and when not transmitting the unemployed sections of the battery flow steadily to line without affecting the workiug transmitters of the other sections.

My improvement thus possesses two distinguishing characteristics: first, that of a main circuit always closed, and second, the passage through this circuit of a smooth current so to speak when all the transmitters are quiescent, each transmitter when in operation throwing its respective portion of said current into vibration, so that there may be a smooth current, and one or more vibratory waves simultaneously transmitted through the circuit or the entire current may be thrown into vibration.

The subject matter claimed hereinafter will specifically be designated.

The accompanying drawings represent a perspective diagram of so much of my approved apparatus as is necessary to illustrate the subject matter claimed.

I have shown this apparatus as constructed in the best way now known to me; but it is obvious that the details of construction of its various parts may be varied within certain limits, in ways well known to skillful electricians.

I have shown three transmitters with their batteries and corresponding receivers at each end of the line, so arranged as to transmit three messages each way simultaneously; but a greater or less number of transmitters and receivers may be employed, and they might be so arranged as all to transmit one way, instead of in opposite directions.

It is deemed unnecessary to describe in detail here the construction of the battery, as it forms no part of the subject matter claimed, and any of the well known batteries of the present day will work effectively with my improved apparatus.

The construction of the transmitters and receivers is fully set forth and described in my Letters Patent and application above-mentioned, and needs no reiteration here.

Each battery is connected with its respective transmitter, by a short circuit or shunt wire. Starting with battery No. 1, G is the ground wire connected at the plus (+) pole of the battery, which battery is connected up in the ordinary way and runs to line at the other or minus (—) end, through the analyzing receivers, F′, E′, D′. The line connects at the other end through analyzing receivers, C′, D′, A′, to the plus (+) pole of battery No. 2, and passes through in the ordinary way to the ground wire G′, at the minus (—) pole of said battery.

The circuit, thus far, is similar to an ordinary Morse circuit, closed, and without a key or other means of making or breaking the circuit.

A, B, C, D, E, F, represents six sets of transmitters, each set being composed of a common open circuit, Morse telegraphic key and a musical tone transmitter; such for instance, as that described in Letters Patent No. 165,728, granted to me July 20, 1875, for improvements in transmitters for electo-harmonic telegraphs. These transmitters are all alike in construction, but each one is tuned to a different pitch, and has a receiver, A,′ B′, C′, D′, E′, F′, correspondingly tuned, at the other end of the line.

Each battery is divided into sections, 1, 2, 3, 4, 5, 6, not by separating or disconnecting its cells, but by throwing a short circuit or shunt wire around each section; for instance, the first short circuit of battery 1, consists of the wires *a b*, the second of wires *b c*, and the third of the wires *c c′*, and so on. The number of cells in each section is determined by the distance the tone is to be transmitted.

Each shunt wire runs through its own key and vibrating transmitter; for instance, in section 1 of battery 1, which is at the line end of the battery, a wire *a*, passes from the minus (—) pole of the battery to one binding screw of the transmitter A, at which point the circuit divides, one branch connecting to line L, and the other to the vibrating bar of the transmitter through the break point, which is in this instance a shunting point. The circuit then passes to the other binding screw, and thence to the key lever.

The anvil or lower point of the key is connected directly with the ends of the wire *b*, which forms the dividing line between sections 1 and 2, forming part of the short circuit of each section, and so on. Now, if the reed or bar of transmitter A be vibrated by its

3194

local battery, (which is omitted from the drawing to avoid complication, but the operation of which is well understood,) and the key belonging to it, and in the same circuit with it be depressed, the shunt circuit around section 1, will be completed every time the vibrating bar or reed makes contact with its great point, thus producing a set of waves or electrical vibrations throughout the line, the waves succeeding each other at the rate per second corresponding to the vibrations of the transmitting reed or bar, which waves will induce corresponding impulses in all the magnets of a power approximating one-sixth of the whole battery.

Although these magnetic impulses are induced in all the magnets in the circuit, one only will make an audible response, except to a very delicate test, which one in this instance will be the receiver marked A′, as one whose reed or ribbon (or reed and box, as the case may be), is tuned correspondingly to the transmitter in operation. All the other sections of the apparatus are connected up and operated in a manner precisely similar, each operating on its own section of battery. Each transmitter differs in pitch from every other one, and has its compliment in its corresponding receiver.

It will be observed that by working with this inproved system, the main circuit is never open, owing to which fact the integrity of each set of waves is preserved in tact, thus rendering analysis easy at the receiving end of the line.

The utility of the device has been amply demonstrated by practical operation.

I claim as my own invention :—

1. The improvement in the art of telegraphically transmitting composite tones, hereinbefore set forth, which consists in working a closed circuit with a continuous current from a main battery, portions of the whole of which current are thrown into vibration at will by the transmitters.

The improvement in the art of telegraphically transmitting and analyzing composite tones, hereinbefore set forth, which consists in working a closed circuit with a continuous current from a main battery, portions of the whole of which current are thrown into vibration at will by the transmitters, each set of vibrations being audibly reproduced by a corresponding receiver.

3. The combination, substantially as hereinbefore set forth, of a series of transmitters each operated by a local battery, a main battery, an electric circuit through which a continuous current flows

from said battery, and shunt or short circuits between the main battery and transmitters.

4. The combination, substantially as hereinbefore set forth, of a series of transmitters, a main battery connected therewith by short or shunt circuits, a closed electric circuit through which a current continuously passes from the main battery, and a series of analyzing receivers included in the circuit.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

WM. J. PEYTON,

JOSEPH S. PEYTON.

2

2196

Sheet 1-2 Sheets.

C. F. Varley.

Telegraph.

No. 78,495. Patented Jun. 2, 1868.

Fig. 1.

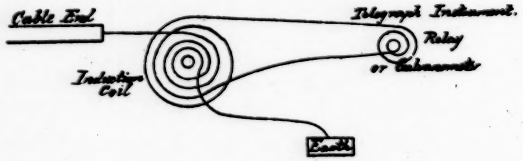


Fig. 2.

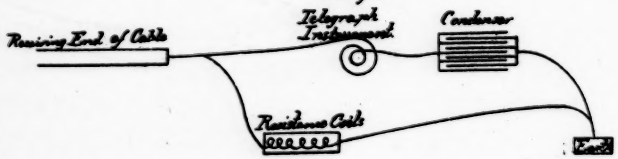


Fig. 3.

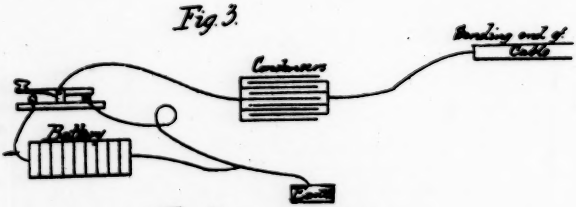
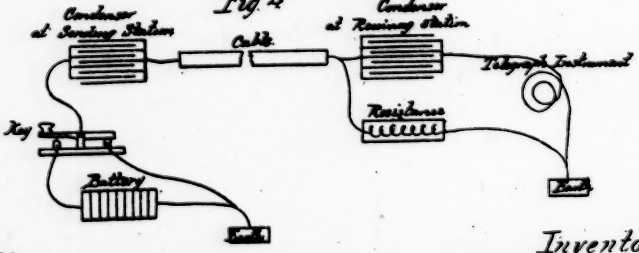


Fig. 4



Witnesses.
M. Bach
J. Page Jr.

Inventor
Cromwell Fleetwood Varley
by his attorney

2197

Sheet 2-2 Sheets.

C. F. Varley.

Telegraph.

No. 78,495. Patented Jun. 2, 1868.

Fig. 5.

Fig. 7

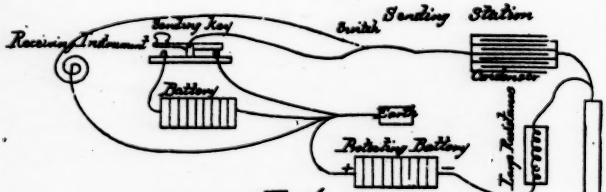


Fig. 6

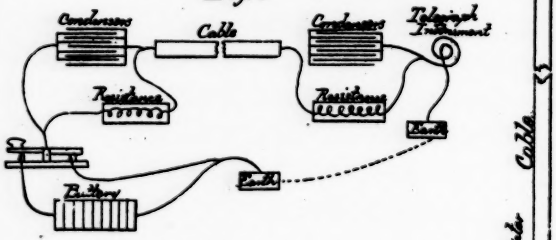
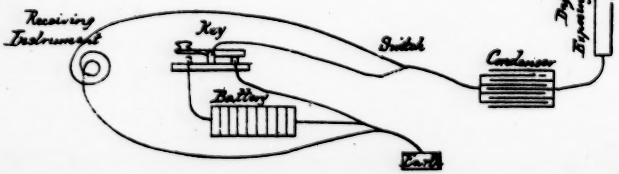


Fig. 7.

Receiving Station.



Witnesses

M Bauly

J. Page, Jr.

Inventor

Cromwell Fleetwood Varley

by his attorney

171 8

(No. 47.) Defendants' Exhibit, Letters Patent to Cromwell Fleetwood Varley, dated April 8, 1870, No. 1044.

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 11.]

UNITED STATES PATENT OFFICE.

CROMWELL FLEETWOOD VARLEY, OF LONDON, ENGLAND. IMPROVEMEN IN TELEGRAPHING.

Specification forming part of Letters Patent No. 78,495, dated June 2, 1868.

To all whom it may concern:

Be it known that I, Cromwell Fleetwood Varley, of London, England, temporaily residing in New York, County of New York, and State of New York, have invented certain new and useful Improvements in Electric Telegraphs; and I hereby declare the following to be a full, clear and exact description of the same.

The objects of my invention are to cut off the disturbance arising from earth-currents, to obtain a high speed of signalling through long circuits, and, should the conductor become partially exposed, to preserve it from being eaten away by electrolytic action.

No means, prior to my invention, had been devised for effecting the first and third of these results. I have devised several other methods less perfect than those hereinafter described, but all embodying the general principle of my invention.

The invention consists of the arrangement of well-known apparatus, whose action, being of an electric and magnetic character, cannot be explained by drawings or models; but the accompanying diagrams and specification will enable those skilled in the art to understand the invention.

The telegraphic signals in this invention are made to depend upon the rate of change of electrical potential, and not upon the strength of the current or charge in the cable.

As the earth-currents—*i. e.*, the electric variations in the earth itself—change their strength slowly, the indications produced by

2199

them with this invention, in which the strength of the signals depends upon the rate of change of strength, are so feeble as to escape notice, and the embarrassment arising from this cause on long lines is, to all practical purposes, avoided.

There are two modes by which this is effected, and a higher rate of signalling through long cables obtained. The first plan is by means of an induction coil. The cable at the receiving end of the circuit, is connected to the primary wire of an induction coil, and through it to the earth. The secondary wire is connected to the telegraph instrument. This arrangement is represented by Diagram No. 1.

Explanation of its action: On a current passing through the primary wire of the induction coil, the iron core becomes magnetized, and this magnetization produces a current in the secondary wire, which acts upon the telegraphic instrument.

When the current in the primary wire has reached its maximum force, and is flowing steadily through, the iron core is magnetized to a certain fixed amount, and then the current in the secondary wire ceases. If, now, any change in the strength of the current through the primary wire occurs, the amount of magnetization of the iron core will vary, and a corresponding current in the secondary wire will result.

The earth-currents seldom pass from zero to their maximum and back again to zero (prior to changing sign) in less than five or six minutes, while the telegraphic signals are generally produced in a small fraction of a second.

With the former, although the currents are often very strong, the rate of change of strength is extended over several minutes, and consequently the current in the secondary wire is very feeble, as its strength is mainly dependent upon the rate of variation of the magnetism of the iron core.

The signalling currents or impulses are much more rapid or sudden, and consequently the variation of the magnetism of the iron core is much more sudden, and the currents generated thereby in the secondary wire are comparatively powerful and distinct.

Thus, then, suppose the earth to send a current through the line—say a positive (+) current from the sending to the receiving station—and to slowly magnetize the iron core, and, for ease of explanation, suppose this earth-current to remain for a time steady and uniform in strength; let, now, the sending-station make a signal. In doing so his battery adds its strength to or opposes the earth-

2200

current, according as the signal sent is + or—, (positive or negative).

This sharp and comparatively sudden addition to or subtraction from the earth-current produces a rapid augmentation or diminution of the magnetism in the iron core, and thus produces a distinct signal in the secondary wire.

For still further explanation, suppose the earth-current to be +, and to have a strength of 100 plus or positive, and the signal current to have a strength of 10, if a positive signal be sent, the current will rapidly rise at the receiving end in the proportion of 100 to 110. This rapid increment of magnetism will produce a positive signal in the secondary wire, corresponding to the increment 10. But if a negative signal be sent, then the battery will be opposed to the earth-current, and the current will rapidly fall at the receiving end in the proportion of 100 to 90, the magnetism in the iron coil will experience a rapid decrease, and a negative signal will be produced in the secondary wire corresponding to the decrement (or negative increment) 10, although the current through the line or cable still remains strongly positive.

As the strength of those secondary signals is almost entirely dependent upon the rate of increment and decrement of the current through the primary wire, and as the slowest line yet constructed need not require so much as half a second to produce a clear signal, while the earth takes five minutes or six hundred half seconds, the current arising in the secondary wire from the earth-current (which although assumed to be ten times stronger, is six hundred times slower) is $\frac{10}{600} = \frac{1}{60}$ part only of the strength of the signal, and the effects of the earth-current are consequently practically cut off.

When signaling through a very long cable, a rapid succession of signals charges the cable and produces an electric wave which is a long while subsiding, and acts at the receiving end in a somewhat analogous manner to the earth current just described. This prevents signals from being transmitted in rapid succession by the ordinary means.

The above apparatus, which may be popularly described as disentangling the short high-crested waves from the large long swells, enables clear distinct signals to be produced rapidly one after the other.

The strength of the signals through the cable or telegraph circuit is produced by the rate of the increments and decrements of current, and not by the current itself; and as an imperfect illustra-

tion, if the great earth current through the cable be compared with an Atlantic swell whose height is five fathoms, but spreading horizontally over five or six hundred fathoms, and whose sides will have an angle of say one hundred and seventy-eight degrees, and if the signals be compared with the ripples produced by the wind upon the back of the swell, and whose angles are each, say, sixty degrees, then an apparatus that will indicate these angles would scarcely notice the angle of one hundred and seventy-eight degrees, which is nearly a straight line (or one hundred and eighty degrees), while the small waves, with an angle each of sixty degrees, would be distinct, and such apparatus would disentangle the small signals from the big swell, paying almost no attention to the latter. Electric waves are entirely different from water waves; but the illustration may serve to explain the action of the former.

The second plan of effecting the above is more expensive in construction, but more perfect in action. A large condenser is inserted in the circuit at one or both ends, according to the circumstances of the case. At the receiving end of the line I prefer the following arrangement (Diagram No. 2), which gives a rapid rate of signaling.

The cable is connected to the one armature of the condenser through the telegraph receiving instrument, and the other armature is connected with the earth. The cable is also connected to the earth by means of a resistance coil, which is best when made of a long length of insulated copper wire, wound round an iron core.

On a current running through the line or cable it finds at the distant end two routes or channels, viz., the resistance coil and the condenser. The condenser route at the first moment offers no other sensible resistance than that of the receiving instrument, while the other, owing to the magnetic inertia of the iron core, offers at the first moment a considerable resistance. The condenser is rapidly charged, and as soon as it is charged to the full force or potential of the current in the cable, all the rest of the electric current goes through the resistance coil to earth, and no more current is shown upon the receiving instrument. If, now, the potential in the cable be reduced or increased a little the change in the condenser is reduced or increased in proportion and a negative or positive signal can be distinctly produced at pleasure, although the electric current or charge in the line or cable has not changed sign, but only varied in strength. The resistance coil, between the cable and the earth, may be dispensed with; but then the little

signal wave does not reach its maximum so rapidly, and consequently the signals are not so rapid (*vide* Diagram 6).

Observe, the receiving instrument may be placed between the second armature of the condenser and the earth or ground, instead of between the cable and the first armature. A condenser may also be employed at the sending end of the line or cable, either with or without a condenser at the receiving end of the line or cable. When a condenser is inserted at the sending end only of the line the resulting signal is very similar to that produced by a condenser at the receiving end only; but the disturbing action of the earth current, however, is more felt when the condenser is only placed at the sending end, because the earth current has to charge the cable in addition to the condenser, all of which charging current has to pass through the receiving instrument. When the condenser is used at the sending end of the cable or line (Diagram 3), the cable is connected to the one armature of the condenser, and the telegraph key to the other armature of the condenser. An ordinary double or reversing key is generally used, so that when the one is depressed a positive charge is communicated to the condenser armature attached to it, and when the other is depressed a negative charge is communicated to it.

If the key had been connected to the line or cable in the usual manner, a constant or permanent current would have been produced through the cable so long as the contact was maintained, and this current would only begin fo die away when the contact with the battery was broken or reversed. But when the condenser is interposed in the circuit, as described, so soon as the current from the battery has charged the condenser, the current from the condenser is arrested and variations in the length of the battery contact be under fixed amount will produce no change in the amount of current thrown into or induced in the cable, In this way great uniformity and regularity of signals are obtained.

At the sending end of the line it is sometimes advisable to use a smaller condenser than at the receiving end, and higher battery power, because the more sharp and sudden the impulse is given the quicker will the signal appear at the distant end.

If the dimensions of the condenser be reduced, say halved, and the battery power be augmented in the inverse ratio, then the shock or impulse will be the same in amount but more sudden, producing a rather more rapid signal at the distant end; but the

2203

disturbing action of the earth currents is reduced as the dimensions of the condenser are reduced at the receiving end.

In some cases, such, for example, as where the Morse instrument is used, it is advisable to connect together the two armatures by means of a very large resistance, as shown in Diagram 6, so that after the condenser is charged the current through the cable shall not entirely cease. Thus the sharp, sudden impulse of the condenser charges the cable and would produce a dot, but not a line or dash. The weak current through the large resistance, however, maintains the current in the cable, and a dash is produced, the Morse armature being held down by this weak current so long as the key is held down.

On the key being elevated the charge condenser is connected to the ground if the condenser be at the sending end; and in discharging itself the condenser produces a short, sharp current in the cable in the opposite direction, which rapidly terminates the signal at the distant end of the cable.

All cables are liable to have their insulation impaired. When this is the case, and the proper conductor is exposed to the sea water the copper is decomposed whenever a positive current is permitted to flow from the copper into the water, forming chloride of copper, which is soluble and effuses itself and floats away.

If the cable be kept always negative to the water the action of the positive current flowing into the wire from the water is to preserve the wire from decomposition.

To effect this I place a condenser at each end of the cable (Diagram 7), and also connect to the cable through a large resistance (or long coil of fine wire), a battery whose positive pole is connected to the earth at a negative pole to the resistance coil. This keeps the cable always negative to the water, and yet the signals through it and the condensers are either positive or negative, at pleasure. Suppose the signal impulse to be a positive one it weakens the negative character of the charge in the cable, and also in the distant condenser, and immediately a corresponding positive signal is produced in the distant instrument.

If the signal impulse be negative it increases the negative charge in the cable and also in the distant condenser, and therefore produces a negative signal in the distant instrument, and thus, although positive and negative impulses are produced at the distant end, the cable has been only less or more negative, but never posi-

2204

A.D. 1870. April 8. N°. 1044.
VARLEY'S Specification.

Sheet. 1.
4 Sheets.

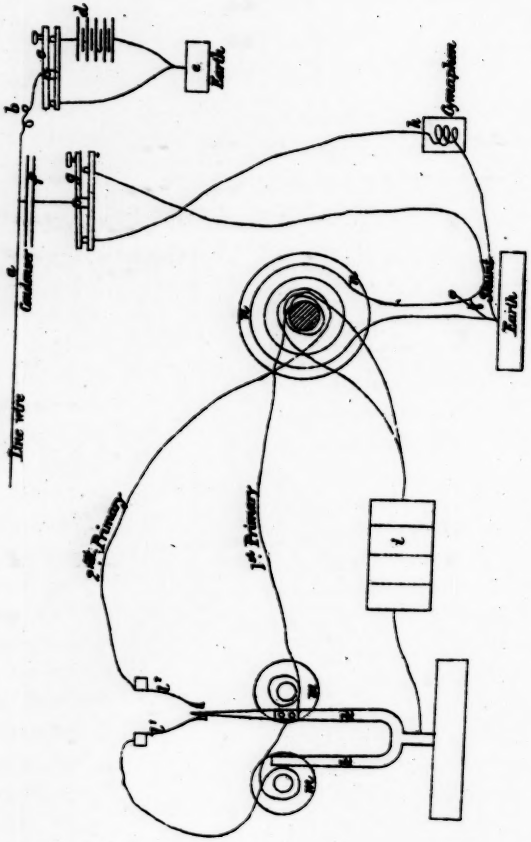


FIG. 1.

2205

A.D. 1870, Appl. 8, No. 1944.
WARLEY'S Specification.

Sheet 2
4 Sheets.

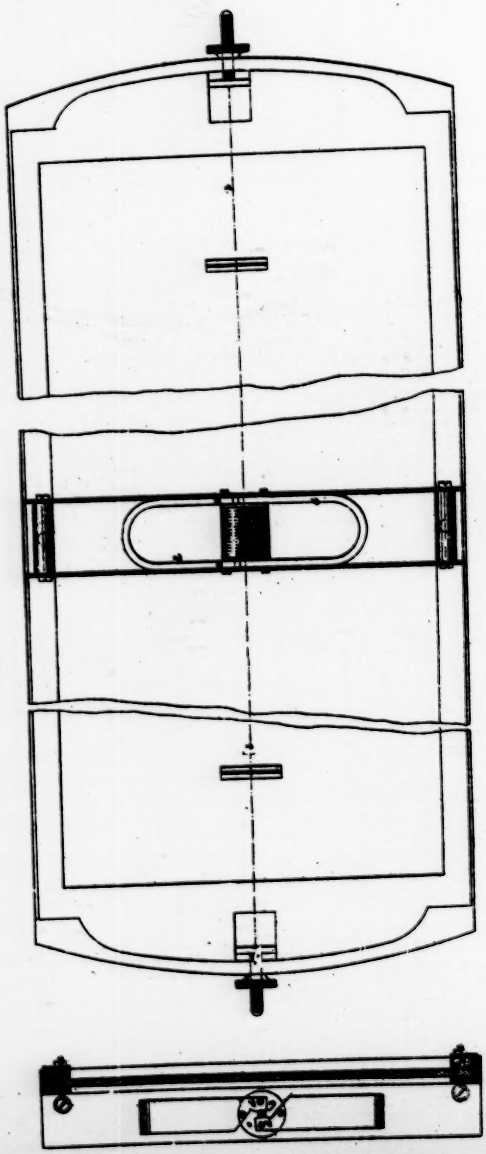


FIG. 2.

FIG. 3.

FIG. 4.

2206

A.D. 1870. April 8. N°. 1044.
VARLEY'S SPECIFICATION.

SHEET 3.
4 SHEETS.

FIG. 5.

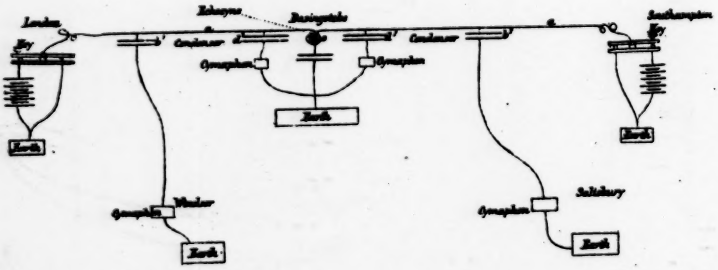
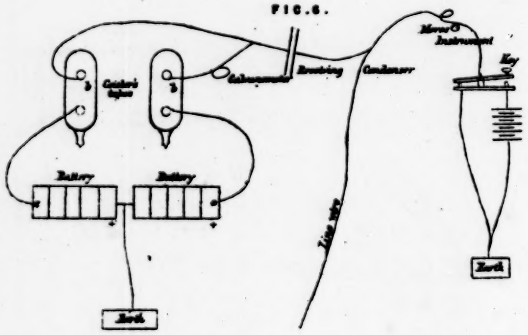


FIG. 6.



AMERICAN BELL TELEPHONE COMPANY, - 13

2207

SHEET 4.
4 SHEETS.

A.D. 1870. APRIL 8. N° 1044.
VARLEY'S SPECIFICATION.

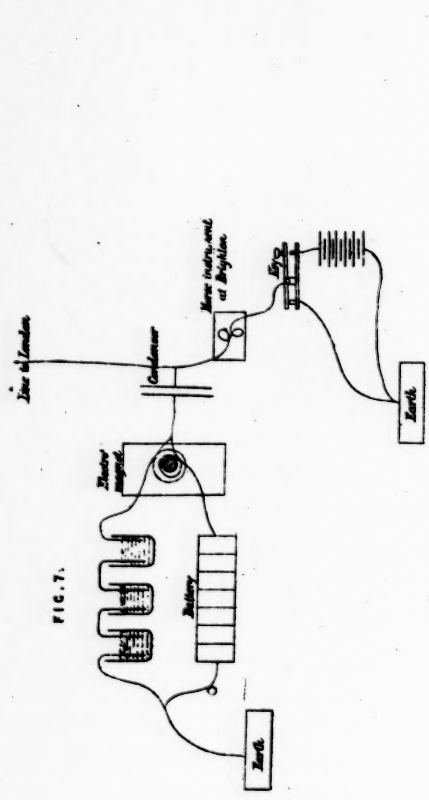


FIG. 7.

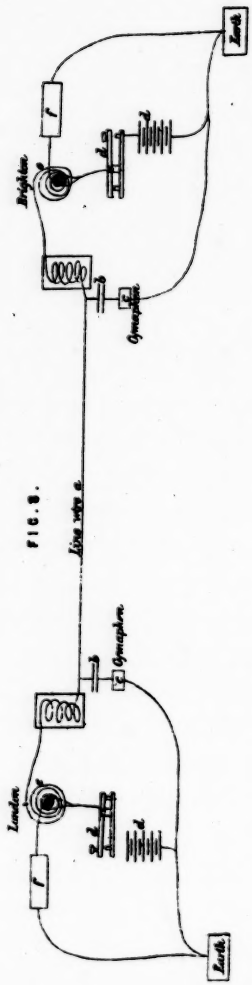


FIG. 8.

2208

tive to the sea, and therefore the conductor has been constantly under the preservative action of the negative current.

Thus, then, the action of the condensers and battery has not been only to cut off the effect of the earth currents and to expedite the transmission of signals, but also to preserve the conductor of the cable from destruction if exposed to the sea water.

In Diagram 7 the place of the switches or commutators is shown. These have been omitted in the other diagrams to simplify them. These commutators are of the ordinary well known form, common to most systems of submarine telegraphing, and are not a part of this invention.

Having now described my invention and the manner in which the same is or may be carried into effect, what I claim and desire to secure by letters patent is :

1. In so arranging telegraphic apparatus as to work by the variation of the increment and decrement of electric potential, and not by the direct action of the electric current itself, as and for the purposes set forth.

2. The use of an induction coil at the receiving end of the cable, one of its wires being connected between the cable and the ground, and the other or secondary wire connected with the receiving instrument, as and for the purposes set forth.

3. The use of a condenser or condensers between the receiving end of the cable and the earth, with or without resistance coils between the cable and the earth, as and for the purposes set forth.

4. The use of a condenser at the sending end of the cable, with or without resistance coils, connecting its two armatures, as and for the purposes set forth.

5. The use of a condenser at each end of the cable, the cable being connected with the ground through a resistance coil and a battery so as to keep the cable always negatively electrified, as and for the purposes set forth.

In testimony whereof I have signed my name to this specification before two subscribing witnesses.

C. F. VARLEY.

Witnesses :

W. BAILEY,

C. G. PAGE, JR.

2209

(No. 48.) Defendants' Exhibit, Johnson Patent, Gray's Magnet Receiver.

J. A. W., Exr.

[Introduced in Record, p. 11.]

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, Greeting:

This is to certify that the annexed is a true copy from the bound volumes of the library of this office of the specification and drawing in the matter of the English letters patent granted John Henry Johnson, July 29, 1874, No. 2646, for Transmitting Musical Tones by Electricity.

In testimony whereof, I, W. H. Doolittle, Acting Commissioner of Patents, have caused the seal of the Patent Office to be herenuto affixed this seventeenth day of March, in the year of our Lord one thousand eight hundred and seventy-nine, and of the independence of the United States the one hundred and third.

[SEAL.]

W. H. DOOLITTLE,
Acting Commissioner.

A. D. 1874, 29th JULY, No. 2646.

TRANSMITTING MUSICAL TONES BY ELECTRICITY.

Letters Patent *to John Henry Johnson, of 47 Lincoln's Inn Fields, in the County of Middlesex, gentleman, for the Invention of "Improvements in the Method of and Apparatus for Transmitting Musical Tones by Electricicy." A communication from abroad by Elisha Gray, of Chicago, County of Cook, State of Illinois, United States of America.*

Sealed the 23d October, 1874, and dated the twenty-ninth of July, 1874.

Complete specification filed by the said John Henry Johnson, at

the office of the Commissioner of Patents, with his petition and declaration, on the 29th July, 1874, pursuant to the ninth section of the Patent Law Amendment Act, 1852.

To all to whom these presents shall come:

I, JOHN HENRY JOHNSON, of 47 Lincoln's Inn Fields, in the County of Middlesex, gentleman, send greeting:

Whereas, I am in possession of an invention for "Improvement in the Method of and Apparatus for Transmitting Musical Tones by Electricity," and have petitioned Her Majesty to grant unto me, my executors, administrators and assigns, Her Royal Letters Patent for the same, and have made solemn declaration that the said invention is communicated to me from abroad by Elisha Gray, of Chicago, County of Cook, State of Illinois, United States of America.

Now, know ye, that I, the said John Henry Johnson, do hereby declare that the following complete specification, under my hand and seal, fully describes and ascertains the nature of the said invention and in what manner the same is to be performed in and by the following statement, reference being had to the accompanying drawings and to the letters and figures marked thereon, that is to say:

This invention relates to a method of producing musical tones of any desired pitch at any point in an electrical circuit, and consists in transmitting a series of impulses of induced electricity of high tension, corresponding in number to the number of audible vibrations constituting said musical tone, through living tissue in contact with any resonant substance, or through a coil surrounding a bar of iron or the core of an electro-magnet, the succession of currents being produced by an induction coil or other apparatus for inducing a secondary current, and being caused by the action of any suitable circuit interrupter situated in a primary circuit.

And in order that the said invention may be fully understood, I shall now proceed more particularly to describe the same, and for that purpose shall refer to the several figures on the annexed sheet of drawings, the same letters of reference indicating corresponding parts in all the figures.

Figure 1 of the drawings represents one form or plan of an electrical apparatus in which these improvements are embraced; figure 2 is a front elevation of the same, and figure 3 is a diagram showing an arrangement of parts and circuits which may be employed in connection with these improvements.

A represents the base or frame of the apparatus; B is an induc-

tion coil of the usual form provided with the usual primary and secondary helices; C is an ordinary vibrating electrotome which, when in action, produces a musical tone by the vibration of its armature and circuit breaking spring *a* of a pitch determined by its rate of vibration, which rate is dependent upon the length, stiffness and adjustment of the spring attached to the armature of the electrotome; C^1 is another electrotome similar to the first with the exception that its spring a^1 is so adjusted that it produces, when in action, a musical tone of a different pitch from that produced by the electrotome C, owing to the different rate of vibration of its circuit-breaking spring a^1. Other electrotomes may be provided having their vibrating springs so constructed and adjusted that when in action the series will produce tones extending through one or more octaves. These electrotomes are situated in the primary circuit of the induction coil B, and when the said primary circuit is broken by the vibration of the circuit-breaking springs, secondary currents are induced in the secondary circuit of the said coil.

D, D^1 are telegraphic keys of the usual form, placed in the primary circuit above referred to, which circuit is divided so that it passes through both keys and both electrotomes. The keys are used for making connection with the battery.

Figure 3 shows the arrangement of the circuits, G being the secondary circuit extending from the induction coil B to the receiving station F, the battery; and H the primary circuit from the battery through the keys; D, D^1, magnets of the electrotomes, C, C^1, and the primary circuit of the induction coil B. E represents a suitable resonant substance at the receiving station, and consists of a hollow cylinder of metal.

The method of operation of the apparatus is as follows: On depressing either of the keys D, D^1, the primary circuit from the battery F will he closed through one of the electrotomes, and the spring or circuit interrupter or of the latter will immediately commence to vibrate, producing a musical tone of a certain pitch, dependent as before stated on the size and adjustment of the spring, and interrupting the primary circuit of the induction coil B. These interruptions will induce secondary currents in the secondary circuit of the said coil, which will correspond in number with the vibrations of the circuit ininterrupter, and the number of musical audible vibrations constituting the tone produced; thus, for example, if the circuit-interrupting spring vibrates one hundred and twenty-eight times per

second, the tone produced is that known as the "fundamental C," and at the same time one hundred and twenty-eight terminal induced currents will be generated in the secondary circuit.

If now, a person places himself in the said secondary circuit and brings his hand or any other part of his body in contact with any resonant substance which is a conductor of electricity, so that the circuit is completed through it, the said resonant substance being either the metallic cylinder shown at E, or a plate of metal stretched above the body of a violin by metallic springs or a sheet of foil paper stretched over a metallic ring or any other suitable resonant substance, the impulses of electricity transmitted through the living tissue of the operator will, from some cause not yet fully understood, produce a corresponding number of vibrations in said resonant substance, and a musical tonewill be given forth of a quality dependent upon the character of the resonant substance, but of the same pitch as that produced by the vibration of the circuit-interrupter at the transmitting end.

Instead of interrupting the primary circuit by vibrating automatic electrotomes, and thereby inducing the secondary current of high tension, which is transmitted to the resonant receiver, the necessary interruptions for this purpose may be effected by any mechanical device which will produce a sufficient number of interruptions per second, to cause a musical tone.

The secondary coil may be dispensed with, and the secondary currents induced in the primary coil, when the primary circuit is interrupted may be transmitted to the receiver for the purpose of producing the audible vibrations.

Another form of the apparatus is constructed as follows: The transmision of sound is effected as in the apparatus above described by the conversion of electrical impulses of high tension through a secondary circuit into audible vibrations, but the apparatus is based upon the principle that an electrical current traversing a coil surrounding a bar of iron or the coil of an electro-magnet causes a slight elongation of the said bar or core, which elongations, if they succeed each other with sufficient rapidity, will result in a vibration of the bar, and the producing of a musical tone. This apparatus is shown at Figure 4, transmitting apparatus being the same as in the apparatus before described, but the receiving apparatus shown at E, consists of an electro-magnet placed in the ordinary circuit; S represents a hollow cylinder of metal which is placed upon the poles of the electro-magnet and intensifies the sound.

The uses to which the apparatus may be applied are various. In telegraphing, for example, instead of transmitting messages by means of a Morse alphabet now in general use, tones of different pitch corresponding to the letters may be employed, which tones can be produced more rapidly than printed or impressed dashes can be made, and their duration would be shorter than the intermissions now required for producing dashes and dots in succession.

A very slight interval would be necessary between the tones to indicate the separation, and as dashes would be indicated by one tone and dots by another, all signals would have the same length. Instead of using one tone for dashes and another for dots, signals could be devised consisting of tones of various combinations. These signals can soon be readily learned and read by any operator capable of distinguishing tones of different pitch, who by placing his ear in contact with the resonant substance, would cause the tones to be produced and still have both hands free to receive the message. By means of a type-writer an operator could record about eighty words a minute.

The amount of current which is neccessary to produce the effec- is almost unappreciable. Less than one-hundredth part of the batt tery power now required enables audible signals to be transmitted over long lines. The apparatus can therefore be employed with advantage on submarine lines, and the rate of transmission over them can be thereby much increased.

As a telegraph apparatus it is simple, economical and rapid in its operation.

The apparatus may also be employed to transmit tunes from one place to another, the vibrating pieces being properly pitched and sufficient in number, even the different parts of a musical composition each simultaneously played in different places may be transmitted to the same place, so that the whole will be there audible. In the latter case a separate circuit and transmitting and receiving apparatus will be required for each part of the musical composition, and it will be necessary to beat time by telegraph for each set of performances.

The apparatus can also be employed with advantage in studying the laws of acoustics.

Having now described and particularly ascertained the nature of the said invention, and the manner in which the same is or may be used or carried into effect, I would observe in conclusion that

2214

Sheet 1
3 Sheets.

A.D. 1874. JULY 29. N°2646.
JOHNSON'S COMPLETE SPECIFICATION.

FIG. 1.

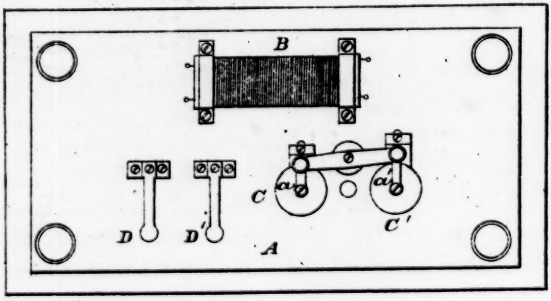
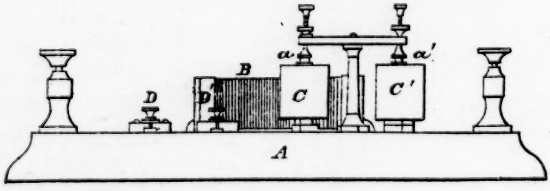


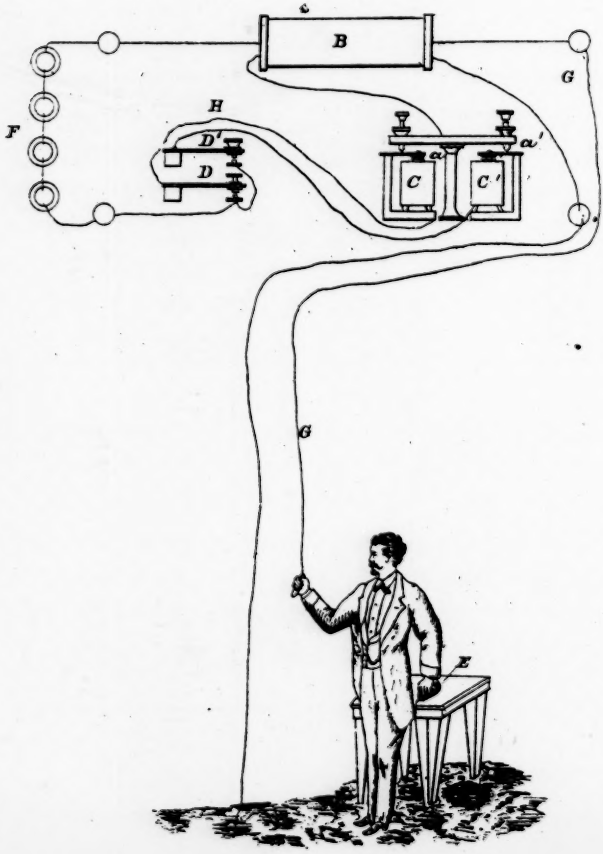
FIG. 2.



A.D. 1874. JULY 29: N°2646.
JOHNSON'S COMPLETE SPECIFICATION.

Sheet 2.
3 Sheets.

FIG. 3.



(No. 49). Defendants' Exhibit, Defendants' Exhibit "Wheatstone and Cooke Patent."

J. A. W., Ex'r.

[Introduced in Record, p. 11.]

, A. D. 1840. ———— No. 8345.

ELECTRIC TELEGRAPHS.

WHEATSTONE AND COOKE'S SPECIFICATION.

To all to whom these presents shall come:

I, CHARLES WHEATSTONE, of Conduit street, Hanover Square, in the County of Middlesex, Esquire, for myself and for William Fothergill Cooke, of Sussex Cottage, Slough, in the County of Berks, Esquire, send greeting:

Whereas we, the said Charles Wheatstone and William Fothergill Cooke, did, by petition, humbly represent unto Her present most Excellent Majesty Queen Victoria, that after considerable application and expense we had invented "Improvements in giving Signals and Sounding Alarms at distant places by means of Electric Currents," and her said Majesty, being willing to give encouragement to all arts and inventions which may be for the public good, was graciously pleased by Her Royal Letters Patent under the great seal of the United Kingdom of Great Britain and Ireland, bearing date at Westminister, the 21st day of January, one thousand eight hundred and forty, in the third year of Her reign, for Herself, Her heirs and successors, to give and grant unto us, the said Charles Wheatstone and William Fothergill Cooke, our executors, administrators and assigns, Her especial license, full power, sole privilege and authority, that we or they, by ourselves or themselves, or by our or their deputies, servants or agents, or such others as we or they should agree with, and no others, during the term of fourteen years from the date of said letters patent, should and lawfully might, make, use, exercise and vend our said invention within that part of Her said Majesty's Dominions called England, Her Dominion of Wales and Town of Berwick-upon-Tweed, in such manner as to us, our executors, administrators and assigns shall seem meet,

and as that we or they shall enjoy the whole profit and advantage arising by reason of the said invention during the said term of fourteen years, and for that end Her said Majesty requires and strictly commands all Her subjects whatsoever within England, Wales and Berwick-upon-Tweed aforesaid, that they shall not, neither directly nor indirectly, make, use or put in practice our said invention or any part thereof, nor in anywise counterfeit, imitate or resemble the same, or make any addition thereto or subtraction therefrom, whereby to pretend himself or themselves to be the inventor or inventors thereof. And whereas the said letters patent contain a proviso obliging us, the said Charles Wheatstone and William Fothergill Cooke, particularly to describe and ascertain the nature of our said invention, and in what manner the same is to be performed by an instrument in writing under our hands and seals, or under the hand and seal of one of us, and to cause the same to be enrolled in Her Majesty's high Court of Chancery within six calendar months next and immediately after the said in part recited letters patent, as in and by the same (reference being thereunto had) will more fully and at large appear.

Now, know ye, that in compliance with the said proviso, I, the said Charles Wheatstone, for myself and for the said William Fothergill Cooke, do hereby declare that our said invention is described and ascertained in manner following, and by the aid of the four sheets of drawings hereunto annexed, that is to say:

Whereas, a former patent was granted to us, the said Charles Wheatstone and William Fothergill Cooke, by his Late Majesty King William the Fourth, bearing date at Westminster, the 12th day of June, one thousand eight hundred and thirty-seven, for improvements in giving signals and sounding alarums in distant places by means of electric currents transmitted through metallic circuits, and whereof the specification stands enrolled in the Chapel of the Rolls, and in that specification it was explained, amongst other matters, how the attractive force of occasional or temporary magnetism which may be excited in masses of iron (that are not magnets of themselves), by electric currents conducted in suitable spiral convolutions around such masses, and be applied for giving signals, and for sounding alarums at distant places. Our present improvements are for the most part further and improved means of applying the said attractive force of occasional magnetism for such purposes.

I shall first describe certain apparatus or mechanism which is

constructed according to our said improvements, and then at the conclusion of this, our specification, I shall point out the particular improvements whereof the exclusive use is granted to us by the said letters patent.

An apparatus capable of giving signals and sounding alarms is represented in sheet 1 of the drawings hereunto annexed. One such apparatus is to be situated at one of the distant places, and another like apparatus at the other of the distant places between which communication of the nature of telegraphic intelligence is to be carried on by giving signals and sounding alarms by means of electric currents transmitted through two long metallic wires extending from one of the distant places to the other, and forming a metallic surface in the manner fully explained in our said former specification; that is to say: The said two long conducting wires or telegraphic wires forming a continuity of metal and being kept insulated one from the other (although laid close side by side), if the end of one of the two wires is brought in contact with one pole of a voltaic battery and the end of the other wire with the contrary pole of the same battery, the two distant ends of both of the wires being conjoined with metallic contact, then the two wires will form what is called a metallic circuit, through the whole length of which an electric current will be transmitted in consequence of a continual transmission of electric action, which, as soon as such circuit is formed, begins to proceed from one pole of the battery along or through all the length of one wire, and then back again through all the length of the other wire with a very great velocity of transmission, in order to return to the other pole of the same battery, the electric current thereby performing a circuit from the battery and back again thereto; and providing the battery is kept in working order, the said electric current or transmission of electric action in a circuit will continue without interruption or cessation so long as the metallic circuit is maintained; that is, so long as the aforesaid contacts of the ends of the two wires with the two poles of the battery (and so long as the continuity of metal throughout the whole length of the two wires and at their distant ends) is continued.

And if one of the said long conducting wires is coiled spirally to form a great number of convolutions around the mass of soft iron, although the same is not magnetic, magnetism will be excited in such mass whenever an electric current is transmitted through the said circuit and convolutions, and by such occasional or tem-

porary magnetism another small piece of iron, being suitably disposed may be attracted and drawn towards the first mentioned mass with a sufficient force and motion to give a small action to some suitable mechanism; but if either or both the ends of the two wires are disconnected from the pole or poles of the battery, or if the wires are disconnected one from the other at their distant ends, or, in short, if the continuity of the metal throughout the circuit is broken at any part thereof, then the electric current will cease to be transmitted, whereupon the said occasional or temporary magnetism will cease also and consequently the aforesaid small piece of iron which was previously attracted by such magnetism as aforesaid, being no longer attracted, may retreat from the said mass of soft iron by the reaction of some small weight or spring which is suitably applied so as to be always operative on the said small piece of iron, with a slight tendency to draw the same away from the mass of soft iron. But when occasional or temporary magnetism is excited therein, then the attractive force of that magnetism will overcome the said tendency so as to give motion to the small piece of iron in manner above stated; but on the cessation of the magnetism the reacting spring or weight will give a contrary motion to the same piece of iron. And in our said former specification the action so produced by the attractive force of occasional or temporary magnetism, and the reaction consequent upon the cessation of such magnetism, was described as being applied to the sounding of alarums in distant places. But the chief object of our present improvements is to obtain (by various means now about to be described) a sufficient diversity of signals from successive alternations of such action and reaction for carrying on a telegraphic communication of intelligence by means of such signals between distant places where duplicates of the apparatus are situated with the two (or in some cases three) long conducting or telegraphic wires extending from one apparatus to the other. The mechanism which we employ for obtaining diversity of signals is of the nature of clock work, and in its simplest form may be described as containing parts answering to the escapement wheel of a clock with its axis, and the seconds' hand fixed on that axis for pointing out seconds on the dial plate. Let the said dial plate be divided into twenty-four or thirty or other suitable number of divisions (instead of sixty as is usual for seconds), and let each division be numbered or lettered with those characters which are to be used for signals, the escapement wheel having

twelve or fifteen teeth, that is, half as many teeth as the number of divisions and characters on the dial; also that any suitable kind of pallets of an escapement or driver and clawker be applied to the teeth of the wheel, with the small piece of iron before mentioned connected with the said pallets or driver and clawker in any such manner as that whenever the said piece of iron is moved, in manner already mentioned, by the attractive force of the occasional or temporary magnetism that is excited by the transmission of an electric current through the metallic circuit, which is formed as aforesaid, the said motion of the piece of iron shall then cause the wheel to be turned round a space just equal to one-half tooth, whereby the hand will be moved away from one division and character on the dial plate, and carried forward to point to the next adjacent division and character thereon; also that whenever by cessation of such magnetism consequent on breaking the circuit, the said piece of iron returns or moves in a contrary direction by reaction of its aforesaid weight or spring, such returning motion shall cause the wheel to be turned round a space just equal to another half tooth, whereby the hand will be moved forwards to point to another succeeding division and character on the dial. This being premised, it may be understood that an apparatus so constructed may be placed at each of the distant places between which telegraphic communication is to be carried on, having two long conducting or telegraphic wires extending from one such apparatus to the other, and one of those wires making like coils or convolutions around the aforesaid masses of soft iron belonging to each apparatus, the two apparatuses being in every respect alike; and when the two wires are conjoined together at their most distant ends, so as to prepare them for forming a metallic circuit, then near the end of one wire being connected with one pole of the voltanic battery, and the like end or the other wire being connected with the other pole of the same battery, an electric current will be transmitted throughout their whole length, and that current will excite occasional magnetism in the masses of soft iron belonging to both the near and the distant apparatus at the same time, and by the action already described of that magnetism the hands of both apparatuses (those hands having been previously adjusted to point to like characters on their respective dials) will be moved simultaneously one division each on their respective dials, so as both to point to a like character thereon; and then by disconnecting either of the wires from its connection with the battery, or by breaking the circuit in any way, the transmission of the electric

current, together with the occasional magnetism which it had excited, ceases in both apparatuses at the same time, whereupon the reaction by weight or spring, already described as being consequent upon such cessation, causes the hands of both apparatuses to move simultaneously one division further on their respective dials, but so as both to point to a like character thereon; then by again reconnecting the said disconnected wire with the battery, or by otherwise restoring the circuit, another repetition of the same action, as above described, takes place, and both hands are thereby moved forward another division; and then on breaking the circuit both hands are again moved another division more, and so on by alternately forming and breaking the metallic circuit in that manner, the two hands may be worked round step by step from one division and character on their respective dials to the next division and character, at pleasure; but nevertheless, the two hands will in all cases point to a like character on their respective dials, wherefore a person situated at one of the said apparatuses can, by alternately forming and breaking the said metallic circuit, cause the hands of both apparatuses to move round alike; and by leaving only very short but regular intervals between each act of breaking and forming the circuit, he can cause the said hands to advance forwards with a continual stepping motion without resting long enough at any one character on their respective dials to indicate any deciding pointing thereto. But when he has thus brought the hand of his own near apparatus, and consequently the hand of the other distant apparatus, to point to some one character which he intends to use at the time for giving a signal, then, by ceasing to go on making and breaking the circuit, both hands will stand still, both pointing alike to the said character for a sufficient time for his correspondent at the place to observe (by the pause that the hand of his apparatus has made opposite to the said character on its dial) that he is to note down that character as a signal given to him, and after a sufficient pause for that purpose, then the first mentioned person may resume the aforesaid operation of alternately making and breaking the circuit, in order to cause the hands of both dials to begin moving forwards again step by step, without any decided pause in their motions, until the hands are brought opposite to some other character which he intends to use for giving his next signal, and then he again discontinues the alternate making and breaking of the circuit in order to leave both hands standing still opposite to the said character for a sufficient time for his correspondent at the distant place to observe

by the pausing of the hand of his apparatus that he is to note down the said character as another signal given to him; and after due pause, the first-mentioned person may begin again, alternately making and breaking the circuit as before, in order to move both hands forwards to the character which he intends to use for giving his next signal, where he pauses again; and so on he gives signal after signal as his communication requires; and when he has by so doing completed a sentence of telegraphic communication, he brings both the hands to point upwards to a blank division or character, and there he leaves them standing still to denote that no signal is intended to be given notwithstanding that the hands stand still; in fact they then indicate blank or nothing; and whenever the hands are left so standing at blank, the near ends of both the telegraphic wires must be disconnected from the two poles of the battery, and the said two ends must be connected one with another by way of preparation of the apparatus, in order that the person at the distant apparatus may be enabled to give signals by it in return if he desires to do so, for his apparatus is in all respects like to the other, and has a battery wherefore, if he separates his two ends of the two telegraphic wires one from the other, and then connects those two ends with the two opposite poles of his battery, then a metallic circuit will be formed, and an electric current will be transmitted through that circuit, and although excited by the distant battery instead of the near one, the current will produce all the same effects as already described, viz, it will excite magnetism in the masses of soft iron in both apparatuses at the same time, so as to cause the hands of both apparatuses to move forwards one division each, and then if the person at the distant apparatus breaks the said circuits both hands will be again moved forwards another division, each by reaction, as already explained, wherefore the person situated at the distant apparatus can give signals to the person situated at the near apparatus, by alternately making and breaking the circuit and by pausing in that alternation whenever he has brought both hands to point to the character which he intends to use for giving a signal. In fact he can do every thing that has been already described as being done by the person situated at the near apparatus, so that the whole apparatus is adapted for communicating telegraphic intelligence in either direction. The construction of the apparatus admits of many modifications in its parts and mechanism; for instance, instead of hand pointing to divisions on the dial, a small circular dial, with the characters marked there-

2225

on, may be fixed on the axis so as to turn round therewith, and being situated behind the dial plate of the mechanism, the said revolving dial will be concealed, except one character at a time, which will be exhibited through a suitable aperture cut out through the dial plate, the effect whereof will be the same as that of a hand, as is well known in ordinary clock-work; also the toothed wheel, or escapement wheel, or ratchet wheel, with its pallets or driver and clawker, may be constructed in various ways well known and commonly used in other mechanism for various purposes, preferring that way which will be most certain to move the wheel without fail one-half tooth by the action resulting from the excitement of the occasional or temporary magnetism, and then one other half tooth by the reaction (of a weight or spring) which attends the cessation of that magnetism. And in order to facilitate the said motion that the wheel with its hand or dial is required to perform, it may have a tendency given to it to turn round, by means of wheel work actuated by a maintaining power of weight or spring in the manner of ordinary clocks, and the anchor or pallets which apply to the teeth of the escapement that in the usual manner of clocks will prevent that wheel from turning more than half a tooth at a time, the action of the occasional or temporary magnetism, and the reaction by weight or spring being operative alternately on the anchor or pallets of the escapement so as to move the same alternately one way, and then the other way, with a like motion to that which takes place in an ordinary clock when its pendulum is removed, leaving the escapement complete, and what is called the crotch for connecting the same with the pendulum; and instead of an escapement or ratchet wheel with teeth projection around its circumference a wheel having pins projecting laterally from its flat surface or surfaces may be used with suitable pallets to catch and detain those pins, and prevent the wheel from moving more than half the space between two of its pins at a time; and instead of applying pallets in the ordinary form of an anchor, movable about a center or axis, they may be applied to a sliding spindle movable endways, in a direction parallel to the axis of the wheel. And mechanism may be employed to facilitate and expedite the alternate making and breaking of the circuit, whereby, as already mentioned, the said action and reaction is rendered operative to turn round the wheel and its hand or its revolving dial without pauses, until the character intended to be given as a signal is indicated, and then to stop with a decided pause. Amongst a diversity of constructions for the parts of the apparatus

which may be used, we have found the apparatuses represented in the drawings to answer the intended purposes, and I shall now proceed to describe the drawings by way of illustrations.

Sheet I. Figure 1 is a front elevation of the box containing the mechanism of clock-work and masses of soft iron with a dial for exhibiting the characters which are to constitute signals, and also clock-work for sounding alarums. Figure 2, is a vertical section, showing the interior mechanism sideways. Figure 3, a front section, to show the interior clock-work in front. Figure 4, horizontal plan, and Figure 5, detached parts to explain the masses of soft iron in which occasional magnetism is excited. The same letters and figures are used to denote the same parts in all the figures. One such apparatus as that represented by those figures is situated at each of the distant places between which the telegraphic communication is to be carried on, the apparatuses at each place being exactly alike. A, A, are the plates of the frame united with pillars like the frame of a common clock. B, the spring barrel for a maintaining power, whereby a train of four wheels and four pinions gives motion to an axis *a*, on which is fixed the escapement wheel *b*, and also the revolving dial *d*, is fixed on the extreme front end of the axis *a*, so as to turn round therewith. The revolving dial *b* is divided into twenty-four spaces, and lettered as represented in figure *d*. The front of the wooden box or case in which the whole is enclosed, has a fixed dial plate *c*, with an aperture in it, behind which the movable dial *d* is disposed so that the characters can be seen one at a time through the aperture. The escapement wheel *b* has twelve pins fixed into its rim and projecting out on each side thereof; parallel to its axis is *a*, the pallets of the escapement are two small upright prongs projecting downwards from a horizontal spindle *e*, which is situated over the axis *a*, and which spindle can slide freely endways in the direction of its length, to serve as a horizontal slider for carrying the pallets; one of the prongs of those pallets being at one side of the wheel *b* is for catching the ends of the pins on that side, and the other prong being on the opposite side of the wheel, is for catching the ends of the pins on that opposite side. The space between the prongs (measured in the direction of spindle *e*) is much less than the length of the pins, wherefore, when the spindle *e* is pushed endways backward, its backmost pallet retreats from the backmost end of one of the wheels in the wheel, and allows the wheel to turn around until the frontmost pallet intercepts the front end of the next following pin in the

wheel *b*, so as to detain the wheel from turning round further than half the space between two of its adjacent pins; and then, if the sliding spindle *e* is drawn forwards endways, its frontmost pallet comes forward out of the way of the front end, and that pin which rested against the said pallet, and allows the wheel to turn round until the backmost pallet intercepts the backmost end of the next following pin in the wheel, so as to prevent it from turning more than another half space between two pins. Note an escapement of a somewhat similar nature has been used in clock-work, and is well known by the French term "eechappement a cheville." The pallets and pins of our escapement are not cut sloping or only very slightly so, because it is not intended that the wheel shall exert any sensible impulse to move the sliding spindle *e* of the pallets endways either way. The small piece of soft iron, V, which is to be attracted by occasional or temporary magnetism, as before mentioned, is fixed fast on the backmost extremity of the sliding spindle *e*, so as to move backwards and forwards with that spindle *e* (see figures 2 and 4), and two small horizontal pins are fastened into the said piece of iron, V, to project out forwards therefrom, and pass through suitable holes in the frame plate, for the purpose of securing the piece of iron, V, and also the pallets of the escapement, from turning round about, as the spindle *e* might otherwise permit them to do. That spindle is not intended to operate as an axis, but as a horizontal slider, *m*, figures 3 and 4, is the reacting spring, whereby the sliding spindle *e*, together with the piece of soft iron, V, and the pallets of the escapement, are always drawn forwards. The acting end of the spring *m* presses forwards behind a small stud which stands up from the sliding spindle *e*, out of the boss by which the pallets are fixed to that spindle, the middle part of the spring *m* is fastened loosely to the frame plate, by one screw, and the extreme tail end of the spring is drawn towards the plate by a regulating screw *k*, by turning which the reacting force of the spring can be adjusted to suit what is requisite for reaction. U U, figure 5, are the masses of soft iron in which occasional or temporary magnetism is to be excited, as before mentioned. whenever it is required. Two such masses, U U, are disposed side by side to form a pair; they are of cylindrical form, and each one has a disk of brass or copper when fastened upon each of its ends, so that with those disks it forms a bobbin, around which is coiled a great length of fine copper wire closely covered with silk thread for insulation of one coil from another, until the bobbin is completely filled with such coils, and

two bobbins thus filled are put together side by side and united at one end of each by a connecting cross piece *w* of soft iron, which is fastened to the end of each piece U by a countersunk screw inserted into the end thereof. At the opposite end of each piece U a piece of soft iron *u* is fastened in like manner by a countersunk screw, but the two pieces *u* have no connection one with the other. The coils of the wire about each of the pieces of soft iron U must go round each piece in the same direction of coiling, and the ends of the wires coiled about each piece U being united together, the whole of the coils around both pieces U will operate like one continuous coiling in the same direction, around the two prongs of a horse-shoe of soft iron, such as was described in our said former specification, and which is commonly called a voltaic magnet, for the two pieces U U, when firmly united together, by the connecting cross-piece of iron *w*, will act the same as the two prongs of a horse-shoe would do, but by being made in two pieces, each having the form of a bobbin, the coiling of the wire can be better done, and a greater number of coils laid on them could be done around the two prongs of a horse-shoe. The mode of making voltaic magnets by coiling of covered wire around pieces of soft iron being well known, no further instructions can be required for making them in the manner shown in figure 5. We prefer to use smaller sized wire for the coils than is commonly used for voltaic magnets, because a greater number of convolutions of small wire can be wound around the wire U within the same bulk, and consequent proximity to the iron, than could be done with such large wire as has been usually employed. A voltaic magnet constructed as shown in figure 5, and as above described, is placed in the apparatus as shown at W W in figures 2, 3 and 4, with the two pieces *u u*, or poles of the voltaic magnet situated opposite to the aforesaid piece of soft iron, V, which is fastened on the end of the horizontal sliding spindle *e*, that also carries the pallets of the escapement, and the ends 21*a*, 21*b*, of the coiled wire are to be connected with one of the two long telegraphic wires, so as to form a part of the metallic continuity thereof, in order that whenever an electric current is transmitted along that telegraphic wire, the said current cannot fail to be transmitted along the spiral convolutions which the coiled wire makes around the two masses of soft iron, U U, that transmission taking place in the same direction around each of the two masses U U, and thereupon they will instantly become magnetic, so that their two poles, *u u*, will exert magnetic attraction to draw the piece of soft iron, V, towards them,

2229

and they will continue to do so as long as such transmission along the said spiral convolutions is continued, but the instant that the said transmission ceases, the magnetism and attraction will cease also, all which are the well-known properties of a voltaic magnet. The said magnet W W, is fixed in place in the apparatus by screwing its cross-piece *w*, of soft iron to a brass or copper support *n*, standing up from a flat tablet R, which is applied on the top of the frame plates A A, of the clockwork, in such manner as to be capable of sliding horizontally by action of a regulating screw, whereof the head *r* reaches to the outside of the case, and by turning that head *r*, the distance of the poles *u u*, of the voltaic magnet from the piece of soft iron V can be regulated, and by that means, together with due regulation of the force of the reacting spring *m* by its regulating screw *k*, before described, the apparatus can be regulated to suit the insensity wherewith the occasional or temporary magnetism is excited, in order that the attractive force of that magnetism operating at the two poles or pieces of iron *u u*, may not fail to draw the piece of soft iron V, towards them with an instantaneous motion, in opposition to the strength of the reacting spring *m*. And also that the said spring *m* may not fail to cause the said piece V, to return or retreat from the poles *u u*, with a like instantaneous motion, as soon as ever the occasional magnetism ceases, and every such motion of the piece of iron V, whether produced by attraction or by reaction, being attended with a corresponding motion of the sliding spindle *e*, and of the pallets of the escapement, they will allow the escapement wheel *b*, and the revolving-dial *b*, to turn round one-half space of the pins in the wheel and one division of the dial every time. And note, the operator may sometimes require to actuate the escapement so as to allow the wheel *b*, and movable dial *d*, to turn round without any excitement of occasional magnetism. For this purpose a small sliding pin is fitted to slide endways through a hole in the front of the case, and has a knob P, on the front end of it, to be touched when required by the finger. A spring *p*, is fixed within the case to press against the end of the sliding-pin, with a tendency to push the knob P outwards. The lower end of the spring *p*, stands opposite to the end of the sliding-spindle *e*, but without touching that end, unless the knob P, and sliding-pin is pushed inwards, for then it bends back the spring *p*, so as to carry back the end thereof against the front end of the sliding-spindle *e*, in order to move the same endways in like manner as occasional magnetism would do, and then on releasing the button P, the sliding-rod *e*, re-

turns by reaction of its spring *m*, wherefore by alternately pressing and releasing the button *p*, the moving dial *d*, can be caused to turn round at pleasure, which is sometimes requisite (in like manner as setting the hands of a clock to time), in order to set the apparatus right at first starting, so that it may exhibit the same character as its corresponding apparatus at the distant place. For whenever the two apparatuses at the near and at the distant places are left standing still in the intervals between making telegraphic communications by them, the dials *d*, of both should always exhibit the blank character indicating that nothing is communicated; or a cross +, may be marked on that part of the dial *d*, to indicate the blank, and whenever either apparatus does not indicate + or blank whilst it is so standing still in the interval between the making of communications, then the person in charge of that apparatus will know that something is wrong, and he must use the button P, to set the dial of his apparatus to show + or blank, and if both apparatuses are set in that manner they will be properly prepared for use, for they will begin aright by exhibing like characters on their respective dials, and then, provided that every part is in good order when they are put in operation by means of alternate excitement of temporary magnetism and cessation thereof, as hereinbefore explained, the mechanism of each apparatus will be operated upon simultaneously and precisely in the same manner, the one as the other, so that the dials *d*, of both will be moved round alike, and they will at all times exhibit like characters, whether they are moving on step by step or pausing or standing still. It is an indispensable condition for the successful communication of telegraphic intelligence that both should exhibit like characters, and whenever from default of attractive force from the magnetism, or of reacting force by the spring end, or maintaining power B, in the clockwork, or from partial derangement of any part, either apparatus fails to move its dial contemporaneously with that of the other apparatus, so as by missing one or more times to get behind the other in the characters which it is exhibiting, then there will be a confusion in the telegraphic communication; but nevertheless the fault will be detected so soon as the person who is giving the signals comes to the close of a sentence or series of signals, and brings the dial of his apparatus to exhibit + or blank, and there leaves it standing still during a sufficient time to denote, as previously agreed, that he has come to such close, because the other dial, although it also stands still, will not indicate + or blank; and if after standing still the sufficient time that is observed to be

the case, then the faulty dial must be set right by applying a finger to the button P, first pressing and then removing it, until the dial is brought round to exhibit its cross or blank. And as to the mechanism which may be employed as hereinbefore mentioned, to facilitate and expedite the alternate making and breaking of the metallic circuit which is to be formed for the transmission of an electric current through the two long conducting or telegraphic wires from pole to pole of the voltaic battery belonging to one of the apparatuses, and which said current will be also transmitted through all the coils around the voltaic magnets W W, of both apparatuses, and by which alternate making and breaking it is that the occasional or temporary magnetism of the voltaic magnets W W, becomes alternately excited and discontinued, so that by the attractive action thereof, and then, by the reaction consequent upon its cessation the clockwork is actuated, as above described, in both apparatuses alike, in order to turn round the dials of both apparatuses simultaneously and similarly, so as to exhibit like characters by both dials, the said mechanism for making and breaking the circuit may be constructed in various ways, but what we prefer, is, to use a movablecircle, having divisions answerable to, and marked with like characters to those on the dials *d* of the two apparatuses, the action of the said mechanism being such that the operator, by merely turning round that movable circle by his hand or finger, will cause the alternate making and breaking of the circuit to take place, as is requisite for actuating the clock-work, so as to turn the dials round step by step, in the manner already explained. And the required alternation of making and breaking will be duly performed by the mechanism now about to be described, without other trouble to the operator than that of turning the said movable circle steadily round about with a tolerably slow motion; and as he does so, the dial *d* of both the apparatuses are caused, by the alternate making and breaking of the circuit, to turn about with a corresponding motion one to the other, and also to the motion that is given by the operator to the movable circle by his hand; for, as the several characters thereof pass in succession, opposite to a fixed index, the dials *d* of both apparatuses will exhibit the same character as that character on the movable circle which is for the moment opposite to or passing by that index; and when the operator ceases for awhile to turn the movable circle, and leaves it standing still with any one of its characters opposite to the said index, then the dials of both apparatuses

will stand still also, and will both exhibit that said character. It will be known by the pause that the dials make in their previous motion that the character which they exhibit whilst they do so pause is to be noted down by the person at the distant appartaus as a signal given to him, but he takes no notice of any of the characters which his dial exhibits transiently and in a rapid succession as it moves slowly round, but it is when it makes a pause that he must observe and note down the character which it then exhibits, as a signal given to him; and, in like manner, the person at the near apparatus who gives the signal whilst he is turning the movable circle round for that purpose, takes no notice of those characters on the movable circle which pass in rapid succession by the index thereof as he turns it round, but he confines his attention for the time to that particular character on the said movable circle which he then intends to use for giving a signal, and he turns the movable circle steadily but slowly round until he brings that particular character opposite to the index, and there leaves it standing during a sufficient pause to denote that the said character is given by him, and is to be received by his correspondent as a signal. And from the office which is to be performed by the said movable circle and its mechanism, we call the same a communicator. A communicator, suitable to be used along with the apparatus represented in Sheet 1 (and already partly described), is also represented in that sheet, figure 6, being a horizontal plan, and figure 7 a side elevation. I is a round wooden board, serving as the base of the communicator, the revolving circle of which is mounted on the upper end of an upright pillar or axis J, standing up from the centre of the base I. K is the revolving circle, which is fitted by its centre on the upper end of the axis J, so as to turn round thereon with an easy motion, but with a gentle friction, in order that it may retain any position that may be given to it. The upper surface of the revolving circle K is divided the same as the revolving dial, figure *d*, into twenty-four divisions, and each division is marked with one of the characters as shown in figure 6, so as to correspond exactly with the dial, figure *d*; and opposite to every character a metal pin *q* is fixed into the rim of the circle K, so as to radiate out therefrom, and the pins *q* form twenty-four handles or figures pins for turning the circle round; by applying the end of a finger to the interval between two of these pins *q*, and moving that finger round in a circular orbit, it thereby carries the circle K round with it. L is a pillar standing up from the base I, just beyond the circle de-

scribed by the ends of the finger pins *q*, for the purpose of supporting two wire pins *s*, *s*, which are fastened one above the other into the upper end of the pillar L, and project out horizontally therefrom in a direction towards the centre of the circle K, one fixed pin *s* being above and the other below the movable pins *q*, which, as they are carrried round in circular motion, pass in succession between the two fixed pins *s*, *s*, but without touching them. The use of those fixed pins *s*, *s*, is to serve as the fixed index to the divisions and characters around the revolving circle K, and also to arrest the progress of the finger when it is moved round in a circular orbit as above mentioned, for, when that finger comes in contact with the said pins *s*, *s*, and is stopped thereby, the circle K will stand with that one of its twenty-four characters at the index pins *s*, *s*, which has been previously selected by the finger (when it was applied to the finger pins *q*), as the character that the finger was to bring round to the index *s*. It may be considered that the revolving circle K on the communicator, with its divisions and characters, is the counterpart of the revolving dials *d* of the clock-work apparatuses, and that the fixed index pins *s*, in designating which of these characters is exhibited, correspond to the apertures in the fixed dial plates *c*, figures 1 and 2, through which the characters of the moving dials *d* are exhibited, and with that understanding the arrangements for alternating, making and breaking the metallic current of the telegraphic wires may be explained as follows: The edge or circumference of the revolving circle K, beneath the part from which the finger pins *q* project out, is divided into twenty-four, and at every other division the edge is cut out to form twelve notches, being half as many as the number of divisions and finger pins *q* in the circle K. These notches are disposed at equal distances apart and are filled up with pieces of wood which complete the circular form of the edge of the rim; but that circular edge is composed of a succession of wood and metal surface alternately. A blade spring *z*, which is fastened to the base I, and stands up therefrom, applies its upper end to the said circular edge of the revolving circle K, so as to press against the same, and by the elasticity of the spring *z*, its said end is certain to preserve an effective contact with that edge as the same turns round, but in so doing the contact of the spring *z* will be alternately on the wood and on the metal, and when it is on the metal the metallic circuit will be established or made, but when on the wood that circuit will be broken. The spring *z* is always kept in metallic communication with one of the poles of the voltaic battery

will stand still also, and will both exhibit that said character. It will be known by the pause that the dials make in their previous motion that the character which they exhibit whilst they do so pause is to be noted down by the person at the distant appartaus as a signal given to him, but he takes no notice of any of the characters which his dial exhibits transiently and in a rapid succession as it moves slowly round, but it is when it makes a pause that he must observe and note down the character which it then exhibits, as a signal given to him; and, in like manner, the person at the near apparatus who gives the signal whilst he is turning the movable circle round for that purpose, takes no notice of those characters on the movable circle which pass in rapid succession by the index thereof as he turns it round, but he confines his attention for the time to that particular character on the said movable circle which he then intends to use for giving a signal, and he turns the movable circle steadily but slowly round until he brings that particular character opposite to the index, and there leaves it standing during a sufficient pause to denote that the said character is given by him, and is to be received by his correspondent as a signal. And from the office which is to be performed by the said movable circle and its mechanism, we call the same a communicator. A communicator, suitable to be used along with the apparatus represented in Sheet 1 (and already partly described), is also represented in that sheet, figure 6, being a horizontal plan, and figure 7 a side elevation. I is a round wooden board, serving as the base of the communicator, the revolving circle of which is mounted on the upper end of an upright pillar or axis J, standing up from the centre of the base I. K is the revolving circle, which is fitted by its centre on the upper end of the axis J, so as to turn round thereon with an easy motion, but with a gentle friction, in order that it may retain any position that may be given to it. The upper surface of the revolving circle K is divided the same as the revolving dial, figure *d*, into twenty-four divisions, and each division is marked with one of the characters as shown in figure 6, so as to correspond exactly with the dial, figure *d*; and opposite to every character a metal pin *q* is fixed into the rim of the circle K, so as to radiate out therefrom, and the pins *q* form twenty-four handles or figures pins for turning the circle round; by applying the end of a finger to the interval between two of these pins *q*, and moving that finger round in a circular orbit, it thereby carries the circle K round with it. L is a pillar standing up from the base I, just beyond the circle de-

scribed by the ends of the finger pins *q*, for the purpose of supporting two wire pins *s*, *s*, which are fastened one above the other into the upper end of the pillar L, and project out horizontally therefrom in a direction towards the centre of the circle K, one fixed pin *s* being above and the other below the movable pins *q*, which, as they are carrried round in circular motion, pass in succession between the two fixed pins *s*, *s*, but without touching them. The use of those fixed pins *s*, *s*, is to serve as the fixed index to the divisions and characters around the revolving circle K, and also to arrest the progress of the finger when it is moved round in a circular orbit as above mentioned, for, when that finger comes in contact with the said pins *s*, *s*, and is stopped thereby, the circle K will stand with that one of its twenty-four characters at the index pins *s*, *s*, which has been previously selected by the finger (when it was applied to the finger pins *q*), as the character that the finger was to bring round to the index *s*. It may be considered that the revolving circle K on the communicator, with its divisions and characters, is the counterpart of the revolving dials *d* of the clock-work apparatuses, and that the fixed index pins *s*, in designating which of these characters is exhibited, correspond to the apertures in the fixed dial plates *c*, figures 1 and 2, through which the characters of the moving dials *d* are exhibited, and with that understanding the arrangements for alternating, making and breaking the metallic current of the telegraphic wires may be explained as follows: The edge or circumference of the revolving circle K, beneath the part from which the finger pins *q* project out, is divided into twenty-four, and at every other division the edge is cut out to form twelve notches, being half as many as the number of divisions and finger pins *q* in the circle K. These notches are disposed at equal distances apart and are filled up with pieces of wood which complete the circular form of the edge of the rim; but that circular edge is composed of a succession of wood and metal surface alternately. A blade spring *z*, which is fastened to the base I, and stands up therefrom, applies its upper end to the said circular edge of the revolving circle K, so as to press against the same, and by the elasticity of the spring *z*, its said end is certain to preserve an effective contact with that edge as the same turns round, but in so doing the contact of the spring *z* will be alternately on the wood and on the metal, and when it is on the metal the metallic circuit will be established or made, but when on the wood that circuit will be broken. The spring *z* is always kept in metallic communication with one of the poles of the voltaic battery

belonging to the apparatus, by means of a wire, part of which is concealed in a groove cut out in the under side of the wood base I, but which wire passes, as shown by dotted lines, from the lower end or root of the spring z to a screw button z^1 at the edge of the base I, and that screw button serves to connect with a wire z^2, which extends from one pole of the battery, suppose, for instance, the zinc pole; then the other or copper pole of the same battery is always connected with the end of one of the two long conducting or telegraphic wires which extend to the distant apparatus—suppose, for instance, with that one of the two which will in future be called 21. Another similar blade spring, 22c, stands up from the base I, and its upper end applies in continual metallic contact with an interior rim beneath the revolving circle K. The metal of that circle is kept, by means of the spring 22c, in continual metallic communication with the end of the other one of the two long conducting or telegraphic wires, which extends to the distant apparatus, and which will in future be called 22, for the lower or root end of the spring 22c connects by a wire concealed in a groove beneath the base I, as shown by dotted lines, with the screw button 22^1, and to that end of the telegraphic wire 22 is connected. There is also a third spring 21c; spring 21, which stands up from the base I and its upper end, applies in continual contact with the edge of a circular wooden rim h, which is fastened to the under side of the circle K, and revolves therewith. The lower or root end of the spring, 21c, connects by a wire concealed in a groove beneath the base I, as shown by dotted lines, with a screw button 21d, which is connected with the line of the long telegraph wire 21, near to that end thereof which is connected, as before mentioned, with the copper pole of the battery, so that the spring 21c becomes a short off branch from that end of the line of the wire 21. And note, for the convenience of connection, there is another screw button c1, which connects by a wire with the copper pole of the battery, and that button always communicates by a wire concealed in a groove, beneath the base I, with the next screw button 21d, to which the end of the long telegraphic wire 21 is connected, wherefore the two screw buttons, 21d and c1 may be considered as points upon the line of the long telegraphic wire 21, near to that end thereof which is always in connection with the copper pole of the battery, and it is at one of those points (for instance, 21d) that the connection with the spring 21c branches off. The said branch and spring, 21c, produce no effect whatever so long as the end of that spring is merely in contact with the edge of its wooden

circle *h*, but there is a piece of metal inlaid into the circumference thereof at one place, to which place the spring 21*c* applies whenever the revolving circle K is turned round, so that the blank character (or +) on the revolving circle K stands opposite to the fixed index pins *s*, and that said piece of metal in the wooden circle *h*, being always in metallic connection with the metal of the circle K, the said contact of the spring 21c with that piece of metal causes the end of the telegraphic wire 21 to become connected with the end of the other long telegraphic wire 22, because, as already stated, the metal of the circle K is kept in continual connection with that wire 22 by the continual metallic contact of the spring 22*c*, wherefore whenever the revolving circle K of the communicator is turned round so as to bring its blank character (or +) opposite to its fixed index pins *s*, then the ends of the two long telegraphic wires 21 and 22 will be connected together, and then those two wires may be considered as conjoined into one very long wire, coming by a long course, 21, from the distant apparatus to the near apparatus, and there making a bend, and then going back again by the long course, 22, to the distant apparatus; and, at the same time, the upper end of the spring *z* applies to one of the pieces of wood in the edge of the under rim of the revolving circle K, so as to break off all connection between the metal of that circle K and the zinc pole of the battery, and consequently all connection between that said pole and the telegraphic wire 22. Hence whenever the apparatus is left at rest, in the interval between successive telegraphic communications, it will have the aforesaid connections of its parts, and the position of the revolving circle, K, will be at its blank character (or +), and that is the position from which every fresh sentence of telegraphic communication, that is to be made by the apparatus, must set out at its commencement; and likewise, as already stated, the moving dials *d*, of both the near and the distant clock-work apparatuses, must then exhibit their blank character (or +), and if either of them does not do so, it must be set right by aid of the knob P, in manner already described.

Figures 1 and *d* and 6 and 7, sheet 1, represent the parts in the said starting position. These circumstances being understood, the mode of giving signals by the apparatus is as follows: Suppose the word D A Y is to be communicated, the character which is to be given as a first signal is to be selected upon the revolving circle whilst the same is standing still, and the finger is then to be inserted into the space behind that finger pin *q*, which radiates out from the

said character (in this instance the letter D is to be selected), then by moving the finger deliberately around in a circular orbit, in the direction of the arrow, figure 7, the revolving circle K will be carried round, and as it moves the revolving dials *d* of both the clockwork apparatuses will move round step by step coincidentally with the motion of the circle K, until the finger gets round to the fixed pins *s*, and there they will stop its further motion with the character intended to be given for a signal (letter D in the present instance) opposite to those pins *s*, and at the same instant both dials *d* will stop also when they are both exhibiting a like character (letter D), and by the pause this dial then makes, the person at the distant apparatus will know that he is to note down that character (letter D) as the first signal given to him. The finger being withdrawn from the finger pins *q* is then removed to insert it afresh behind the finger pin *q* which radiates out from that character which is to be used for giving a second signal (in this instance letter A), and by the time that a sufficient pause has been made for noting down the former signal, then the revolving circle K is again moved deliberately round by the finger until the further motion of the finger is stopped by the fixed pins *s*, and the circle K will also stop with the character in question (letter A) opposite to the pins *s*, and the revolving dials *d* will both have moved round to the corresponding motion to that of the circle K, and will stop when it stops, and will then exhibit a like character to that at which the circle K has stopped (viz., letter A), which the person at the distant apparatus will note down; and then in like manner the third signal (letter V) will be given, after which, if the intended communication is completed for the present, that fact is to be expressed by turning the revolving circle K until it stops at its blank character (or +); both dials will do the same, and then all the parts will be at their starting position, as they were at the commencement; or if the communication is not finished, but only a word of an intended sentence is completed, then the character (—) is to be used as a signal denoting the completion of a word, and that may be followed by commencing the next intended word. And note, it will be evident that the extent to which the revolving circle K will require to be turned round for making each signal will vary very much; for example, in the instance above mentioned of the word D A Y the first letter D, required the circle K to be moved four divisions, then the second letter A required a motion of twenty-one divisions, and the third letter Y twenty divisions, after which it required a motion of three divisions more to bring the parts to

their starting position, viz., the blank character or (+), or if it was the (—) instead of the blank, a motion of only two divisions instead of three would have been requisite. To explain the operation of making and breaking the circuit in detail, it must be recollected that at the starting or resting position, when the revolving circle K and the dials *d* were all standing at their blank character (or +), as appears in the drawing, that the spring *z* was then in contact with a piece of wood on the lower rim of the revolving circle K, and then therefore the metallic circuit was broken, because the zinc pole of the battery was thereby disconnected from the long telegraphic wire twenty-two, to which that zinc pole belongs; and although the other or copper pole of the battery remained connected with the end of the other telegraphic wire twenty-one, that one connection alone would not produce any of the effect of a circuit; and furthermore, the end of the two telegraphic wires twenty-one and twenty-two were connected together by the off branch from the end of the wire twenty-one, at twenty-one *d*, to the spring twenty-one *c*, because that spring was then in contact with the piece of metal of the wooden circle *h*, which piece of metal is part of the metal of the revolving circle K, and that metal is always in connection by means of the spring twenty-two *c* with the wire twenty-two, so that it may be considered as the end thereof; therefore, at the said starting or resting position no circuit being formed, there is no transmission of an electric current, through the long telegraphic wires, nor is any magnetism excited in the voltaic magnets of either of the clock-work mechanism the pieces of soft iron *v* in each clock-work will be withdrawn from the pieces of iron *u u* at the poles of the magnet, by the reaction of the spring *m*. These circumstances being understood, it is easy to trace what change takes place when the revolving circle K first begins to move around the piece of metal which is in contact with the spring 21 *c*, passes away therefrom, leaving that spring in contact with the wood of the circle *h*, and thereby the previous connection between the near ends of the two telegraphic wires 21, 22 (that was effected by means of the spring and off branch 21 *c*) is broken, and the ends of the two telegraphic wires become disconnected one from the other, but still leaving the copper pole of the battery in undivided connection with the end of telegraphic wire 21; and as there is only one piece of metal in the wooden circle *h*, the ends of the two telegraphic wires will continue disconnected all the time the revolving circle K goes round until it regains its resting position. Also by the same first motion of the revolving circle K, the piece of

wood in the lower rim *h* thereof, with which the upper end of the spring *z* was in contact, passes away from that spring, and a metal part of the said rim *h* come round into contact therewith; by that contact with the metal of the revolving circle K, the zinc pole of the battery becomes connected with the end of the long telegraphic wire 22 (whereof as before mentioned, the revolving circle K may be considered as one end), the copper pole of the battery being in connection, as already mentioned, with the end of the telegraphic wire 21; also the distant ends of the two telegraphic wires 21 and 22, being connected one with the other, in consequence of the communicator at that distant end being at its resting position and effecting the connection of those ends in the same manner as already described, wherefore, under those circumstances, the metallic circuit is formed, and an electric current will be transmitted through all the length of both the long telegraphic wires 21 and 22, and consequently through all the convolutions or spiral cores W, W, which either of those wires makes around the masses of soft iron, U, U, or voltaic magnets in the clock-work apparatus, as well at the distant as at the near end of the long telegraphic wires and instantaneously on the commencement of such transmission through the said coils, the occasional or temporary magnetism of the masses U, U, is excited, so that the pieces of iron *u*, *u*, at their poles attract the pieces of soft iron B towards them, overcoming the reacting spring *m*, and causing the escapement to let the wheel E move around half a pin and the dial *d*, one division so as to exhibit the next adjacent character to the blank character (or +), viz.: the letter A, which is the same character that the revolving circle K then presents to its index pins *s*; then, as the revolving circle K moves onwards, the metal in its rim *h* passes away from contact with the spring *z*, and a piece of wood in that rim comes to that spring, whereby the connection that it made a moment before with the zinc pole of the battery is disconnected, and the circuit is broken, and then the transmission of the electric current ceases, together with the occasional magnetism which the transmission has occasioned; consequently the poles *u*, *u*, of the voltaic magnet cease to attract the piece of soft iron V, and then the force of the reacting spring *m* draws the said piece V away from those poles *u*, *u*, and causes the escapement to let the wheel *b* move round another half pin, and the dial *d* another division so as to exhibit the next adjacent character to the former, which being the letter A, this will be the letter B, and the revolving circle K also presents its letter B to its index pins S, then as the revolving circle

K moves onwards the piece of wood in its rim *h* passes away from its contact with the spring *z*, and the metal part of that rim comes into contact, thereby making the circuit again, and instantly it transmits an electric current, which produces a renewal of all the effects above described, including a further advance of the dials *d*, and the exhibition of their next character (viz. letter C); and as the revolving circle K continues to move onward always in the same direction, the metal of its rim *h* passes away from its contact with the spring *z*, and is succeeded by a piece of wood, and the circuit is broken again as before, and that causes the dial to exhibit their next character (viz: letter D). In that manner the circuit is alternately made and broken by action of the revolving circle K, with the certainty of being decidedly made and decidedly broken at every alternation; and if all the parts are kept in good working order there will be no failure of action in the dials *d* to exhibit a succeeding character for every succeeding alternation, although alternation may be made to succeed each other with extreme rapidity by turning the revolving circle K briskly round; and in order to avoid loss of time it will be desirable to turn it as quickly, as it is found by experience that the action of the alternate making and breaking of the circuit, and the consequent operation of the voltaic magnets on the escapement and clock-work, can be performed without risk of failure to turn the dials correctly, but how quickly that may be will depend upon the perfection of the action of the clock-work apparatus and voltaic magnets, the conducting power and insulation of the long conducting or telegraphic wires, and the perfect contact of all the parts which are to form continuity of metal for the circuit. And although one of the apparatuses at one end or terminus of the line of the long telegraphic wires has been heretofore called the near apparatus, and the apparatus at the other end or terminus of that line, the distant apparatus, nevertheless that distinction was only used to facilitate the explanation and the description of the drawing. Sheet 1, which represents only one apparatus, and that one was considered as the near apparatus, but in reality no such distinction can be fairly established between the two apparatuses, because they are both precisely alike, and either one can be used to communicate signals to a person situated at the other apparatus, all that is requisite to be observed is, that whenever the two apparatuses are left standing still in the interval between telegraphic communications, that the revolving circles K of their several communicators shall be left standing at their blank character (or +), in which case all the

2240

ends, that is, each of the ends of the two long telegraphic wires will be connected together by the contact of each of the springs 21*c*, with the piece of metal in the wooden circle *h* of the communicator of each apparatus, as already fully described, whereby the ends of both the telegraphic wires will stand thus connected at each terminal apparatus, and then in that state the whole apparatus is ready for operating to communicate the telegraphic intelligence in either direction between the two terminal apparatuses. For if the revolving circle K of either one of the communicators is turned round it will operate in every respect in the manner already explained to give signals at the other apparatus. That apparatus at which signals are to be received being invariably kept with its communicator standing at its blank (or +) in order that it may keep up the requisite connection between the ends of the two telegraphic wires at that apparatus; and although it has been hitherto described as if there were only two of the apparatus, such as represented in Sheet I, one being situated at each of the distant places between which telegraphic communications are to be carried on by aid of two long conducting or telegraphic wires, extending from one of those places to the other, nevertheless it is to be understood that any number of such apparatuses may be disposed on the line of the said telegraphic wires at intermediate places between the two termini or extreme ends thereof, and the coils of wire around the voltaic magnets in each such intermediate apparatus being connected with one of the two long telegraphic wires, so that the said coils constitute a part of the length or extension of the metallic continuity of that wire, and so that the electric current which is to be transmitted through such telegraphic wire cannot fail to be transmitted through all the length of those coils around the voltaic magnets, then it is evident that the voltaic magnets and the clockwork mechanism of every such intermediate apparatus will be caused to operate in every respect in the same manner as the two distinct apparatuses hereinbefore described, do at the same time operate, and, therefore, so as to exhibit like signals by their dials. Hence, whatever signal is given from the person at the near apparatus at one end of the long telegraphic wires to his correspondent at the distant apparatus at the other end of the same wires (or *vice versa*, in a contrary direction), the same signal will also be given at every intermediate apparatus, and may be observed by persons stationed at them, who will become spectators, or all telegraphic communications that are going on in either direction between the two termini,

and whenever such signals are intended to be given, especially to persons so stationed at any of the intermediate apparatuses, the series of such especial signals must be prefaced by some preconcerted signal to signify that intention, and also to signify from which of the two terminal apparatuses the said signals are given. This supposes that the said intermediate apparatuses are not provided with any communicators or voltaic batteries, whereby persons stationed at them can be enabled to operate upon other apparatuses at a distance, so as to give signals from the intermediate apparatus, as well as receive signals thereby; but a voltaic battery and a communicator, such as Figures 6 and 7, may be applied to any intermediate apparatus. And in case one of the long conducting wires (for instance the wire 21) is brought to the communicator of the intermediate apparatus, and its metallic continuity may be there disconnected when required, so as to divide its total extension into two portions, one portion extending from the intermediate apparatus to the apparatus at one terminus, and the other portion extending from the intermediate apparatus to the apparatus at the other terminus. The ends of the disconnected wires 21 are connected with the screw buttons 21*d* 22*d*, by which connection their metallic continuity is again restored, for, as has already been explained, when the communicator is standing at its starting position the screw button 21*d* is connected by means of its off-branch wire 21*c* with the blade spring 21*c*, which is then in contact with the piece of metal in the wood rim *h* of the revolving circle K, with the metal of which circle the blade spring 22*c* is in constant contact, and that blade spring 22*c* is united by its branch-off wire with the screw button 22*d*, to which the other disconnected end of the long conducting wire 21 has already been united. The communicator of the intermediate apparatus is thus placed in exactly the same position with respect to its own apparatus, and the two apparatuses at the two termini for giving and receiving signals as the two terminal apparatuses were with each other.

The diagram Figure 9, sheet II, with the writing thereon, is for the purpose of explaining the general course of the long telegraphic wires 21 and 22, and their connections with the voltaic magnets W W of the two terminal apparatuses, together with the requisite branches, which have been already described, for connecting the communicator K and voltaic battery of each apparatus with the ends of the telegraphic wires 21 and 22. If the diagram, Figure 9, is considered without the dotted lines it will represent proper ar-

rangements for a simple system of two terminal apparatus with their telegraphic wires, without any sort of intermediate apparatus, all the arrangements of which simple system have been already fully described in detail.

But if the parts drawn in dotted lines are also included then the same diagram, Figure 9, will represent the entire system of two terminal apparatuses, with a complete intermediate apparatus provided with its voltaic battery and its communicator, so as to be capable of giving signals, as well as its clock-work mechanism, for receiving signals.

Figures 20 and 21, sheet II., represents another form of the apparatus for the attainment of the same objects as the apparatus represented in Figures I, II, III, IV, Sheet I, viz., for the giving of signals by means of the alternate attractive force of a temporary magnet and the reaction of a spring, but in the present apparatus there is no maintaining power for the purpose of revolving the hand or dial for the indication of signals, but the movement of the dial or hand is caused solely by the alternation of the attractive force of temporary magnetism and the reaction of a spring, which is caused to produce effects similar to those produced by the apparatus already described in Figures I, II, III, IV, Sheet I. I shall employ the same letters as are used in those figures to indicate similar parts in the present apparatus. A is a plate supporting the various portions of the mechanism; *a* is the axis, steadied by a light spring; on this axis is fixed the escapement little *b*, and also a light revolving dial or hand *d*; that dial may be divided and lettered as before described, and the escapement wheel *b* must have a corresponding number of teeth. The pallets or clawker and driver are two very delicate springs terminating in claws projecting from the sliding spindle *e*, with a piece of soft iron V projecting in the other direction, towards the magnet W; one claw of the pallet presses gently on one side of the wheel *b* for the purpose of catching the tooth in that wheel where the piece of soft iron V is attracted by the magnet, and draws it by its forward motion the space of one-half tooth in the direction of the arrow. The other prong on the other side of the wheel *b* is adapted for driving with its claw another tooth in the wheel *b* for another half tooth, as soon as the temporary magnetism has ceased to attract the piece V, whereupon the spindle is pushed back by the small spring *m*. It is obvious that when, by employing the communicator and its accessories, Figures 6, 7, Sheet I, an electric current shall be made to pass by the wires 21*a*, 21*b* through

the coils around the magnet *w*, the same will become magnetized and will attract the piece of soft iron V, and the wheel *b* will be advanced half a tooth, as already explained, whereby the hand on the dial on the axis of the wheel *b* will be made to advance, but on a cessation of the current by a further movement of the communicator the spindle will be forced back by the spring *m*, as the magnet will no longer attract the piece of soft iron V, and a further advance of the hand or dial will be the result; and in both instances a signal corresponding with that indicated by the communicator will be exhibited, all which is so closely corresponding with the action of the apparatus already so fully described as to need no further explanation. And, whereas, our aforesaid improvements have been hereinbefore described, as if the motion of the dial or hand, Figure *d*, Sheet I, always depended upon the attractive power of temporary magnetism and the reaction of a spring *m*, but a magnetic needle, placed within a multiplying coil, may be made to effect the same object, Figures 22 and 23, Sheet II, represent such a magnetic needle in its coil or multiplyer, Figure 22 being a front view and Figure 23 a plan. If the ends of the wire 21*a*, 21*b*, which form their coils around *d*, the magnetic needle W are made to form part of an electric circuit, and if an electric current be transmitted through those coils, the magnetic needle will be deflected into the position represented in the drawing, and the pallet *g* fixed upon the axis *a* of the magnetic needle will force the escapement wheel *b* half a tooth in the direction of the arrow; then if the electric current were to be transmitted in a contrary direction through the said coils, the deflection of the needle will be reversed and the opposite arm of the pallet would push the escapement wheel *b* forward through the space of another half tooth and so on, and the hand or dial *d*, Figure 23, on the axis *a*, would indicate a fresh signal with each such motion, and at each successive change of the deflection of the magnetic needle, caused by the course of the electric current through the coil W being reversed, a fresh indication would be given by the dial or hand in like manner, as hereinbefore already explained.

And respecting the sounding of alarums by the apparatus represented in Sheet I., and hereinbefore described, the same means for that purpose as were described in our said former specification in reference to figure R, Sheet II., of the drawings thereto annexed, and as were claimed at the conclusion of that specification as the seventh particular of the improvements secured to us by our former Letters Patent of the 12th of June, one thousand eight hundred and

2474

thirty-seven. But in applying that mode of sounding alarums in conjunction with our present improvements, now describing the same voltaic magnet, W, W, figures 2, 3, 4 and 5, that we have already described, and its manner of action for giving signals, is also rendered available for sounding alarums. For this purpose the tablet R which sustains the magnet W, W, as before described, is in fact a dove-tailed groove in which a dove-tailed slider N is fitted so as to move horizontally across the direction of the length of the voltaic magnets W, W, and that magnet is fixed to and supported by the slider N, so as to be moved thereby, and supporting cock N for the magnet *b* being screwed to the slider N, and a stem extends horizontally from that slider through the wood case to the outside, having a head O on the end by which it can be moved from the outside; when the head O is pulled out as far as it will come out, the slider N is thereby moved so as to place the voltaic magnet W, W in the position shown in the drawings, and hereinbefore described with the poles *u*, *u* of the magnet W, W, opposite to the piece of soft iron V of the escapement, but when the head O is pushed in as far as it will go then the slider N, with the magnet W, W, will be removed away from the piece of soft iron V, and will by the same motion be brought opposite to another like piece of soft iron K, which belongs to the alarm, and which piece X is fastened on the extreme end of a horizontal sliding spindle *x*, whereon one detent or pallet is also fastened, and whenever the piece X is not attracted by magnetism, that pallet intercepts a pin in the fly wheel *y* of the alarum wheel work in order to detain that fly wheel from moving, and consequently to prevent the alarum from sounding. The sliding spindle *x* is provided with a reacting spring 1, having a regulating screw, the same as the regulating screw *k* for the reacting screw *m* to the slider *e* of the escapement already described. The wheel work for sounding the alarum is actuated by a main spring S, which, by a cog-wheel and pinion, turns the serrated tooth wheel *d*, which, by acting on suitable pallets, moves the hammer of the alarum backwards and forwards so as to strike the bell H and sound the alarum. On the axis of the serrated wheel *c* is a cog-wheel which, by a pinion, turns the fly wheel *y* round whenever the piece of soft iron X is attracted by the excitement of occasional or temporary magnetism in the voltaic magnet W, W, when it will draw the spindle *x* endways, so that the detent thereof will release the pin in the fly wheel *y* and allow the alarum to sound, and it will continue to do so until the cessation of the said magnetism

2245

when the reacting spring 1 will move the sliding spindle *x* endways, so that its pallet will again intercept the pin in the fly-wheel and stop the alarum. Every apparatus, whether terminal or intermediate, being provided with such an alarum, it is to be kept prepared for sounding by always pushing in the head O as far as it will go, and winding up the springs S and B, if requisite, whenever telegraphic communications have been concluded for the present, and all the several apparatuses being left in that state will be ready to sound their alarums, and call attention to them, and all the alarums, when so prepared, will be sounded simultaneously if the communicator of any one apparatus is turned away from its resting position, that is, at its blank character (or +) or to the next adjacent character, letter A, for instance, or letter C or E, or any others, whereby occasional or temporary magnetism will be excited in the several voltaic magnets of the different apparatuses; and every person having charge of an apparatus, or hearing the alarum thereof beginning to sound, must go to the apparatus, and after due pause and attention to the manner in which the alarum is sounded, he must then draw out the head O, which will remove the voltaic magnet away from the piece of soft iron X of the alarum, and bring it opposite the piece of soft iron V for the escapement, and then the apparatus will be ready for use for giving signals in the manner already fully described. And note, as the manner of sounding the alarums admits of considerable diversity by making pauses in the ringing, and varying those pauses, such variations may, by previous concert, serve to convey prefatory information as to the intention of the series of signals which are about to be begun, or to denote which of the intermediate apparatuses is to expect to receive signals, and from which terminal apparatus they will be given. If the occasional magnetism is only excited for a moment and then discontinued, the fly-wheel *y* may be stopped by its pin and detent when it has made only one turn, and that will produce a certain number of blows of the hammer, and then after a pause another like sounding may be made; or if the magnetism is kept up a little longer, the fly-wheel may be allowed to turn twice round before it is stopped, or thrice, so as to vary the manner of sounding, as well as by varying the pauses.

And, whereas, another former patent was granted to the said William Fothergill Cooke by Her present Majesty, bearing date at Westminster the eighteenth day of April, one thousand eight hun-

3246

dred and thirty-eight, for improvements in giving signals and sounding alarums at distant places by means of electric currents transmitted through metallic circuits, and whereof the specification stands enrolled in the chapel of the rolls, and in that specification it was, amongst other matters, explained, and was claimed at the conclusion of that specification, under the head designated part F, in reference to the sounding of alarums, how the angular motion of a magnetic needle that is produced by an electric current transmitted through coils surrounding a space wherein that needle is included, can be caused to disengage the detaining detent or stop of any sufficiently clock or watch work alarum, so as to allow the wheel work thereof to be put into motion by the mechanical force and action of its own mechanism in order to sound the alarum by action of that mechanism. And although an alarum can be sounded in that manner by the application of a very slight force for the purpose of removing the detent, nevertheless, as it is essential to that mode that the magnetic needle should exert the whole of the force requisite for that purpose, part of our present improvements now about to be described is for sounding an alarum by aid of the angular motion of such magnetic needle when the deflecting force thereof is only sufficiently strong to cause a slight angular motion of that needle, even although the needle of itself should not have sufficient force to produce any sensible mechanical action. This improvement is effected by the addition of a hammer F, figure 17, sheet IV., which is movable about a horizontal axis as a center of motion, and which hammer is lifted by means of pins in a wheel *v*, which is turned regularly round by the maintaining power of the clock-work to which it belongs with a continual motion, so that by the pins pressing in succession upon the tail or short end of the hammer F, its head will be caused to strike blows at regular intervals, but a stop *b* is fixed in a suitable position to check the descent of the hammer, and it strikes its blows upon that stop *b*, except when the alarum belonging to the said clock-work is to be sounded. The clock-work may be of any ordinary construction, urged by a maintaining power, and regulated by a pendulum or otherwise, so as to keep constantly going; and if it is adapted to give a speed of two revolutions of the wheel *v* in a minute, when there are four pins in that wheel *v*, the hammer F will strike eight times in every minute on the stop *b*; and immediately beneath the head of the hammer F the detent D of the alarum part of the clock is situated, by which detent D the wheel-work of that alarum is detained and pre-

vented from sounding; but by striking on the stop *b* the hammer F is prevented from descending far enough to come in contact with that detent D, and therefore the blows of the hammer have no effect thereon, unless some piece of metal is interposed between the hammer F and the detent D, and then the blow of the hammer on the interposed body would be communicated to the detent D, so as to depress the same sufficiently to release the wheel-work of the alarum, and then the alarum will be sounded by the action of its own mechanism. The said interposition of a piece of metal between the hammer F and the detent D is effected by the upper end of the magnetic needle G, when the same is caused to perform an angular motion about its center by action of an electric current as aforesaid, and however slight the deflecting force of the needle may be, if it is sufficient to produce so much angular motion of the needle as to interpose its upper end between the detent D and the hammer F, it will suffice for sounding the alarum, because it has only to transmit to the detent D the blow of the hammer which was before inoperative thereon. The manner by which the requisite angular motion of a magnetic needle is obtained by means of an electric current, having been fully explained in the said former specifications, need not be repeated. And it is obvious that other machinery, actuated by a maintaining power, with forcible motion, and capable of regulating the speed of its own motion, may be made to perform the duty above ascribed to clock-work in alternately raising and letting fall a hammer, or otherwise striking, so as to cause the discharge of a detent in consequence of the interposition of the end of a magnetic needle, or else of any hard substance which may be moved or cause to be moved by an electric current, whether a magnetic needle or a piece of iron, attracted by temporary magnetic attraction, so as to become interposed between the body so moved by machinery and the detent of the alarum. And although our aforesaid improvements have been hereinbefore described, as if the aforesaid occasional magnetism in the voltaic magnets W would always be excited by an electric current, excited by a voltaic battery, yet it is not essential that the electric current is caused by any means to pass through the coils round the magnet W, occasional magnetism will be excited in such magnet by such current, and all the effects hereinbefore described as arising from the aforesaid excitement of occasional magnetism, by means of an electric current excited by a voltaic battery, will follow in the same manner from an excitement

of a like continuation of occasional magnetism by an electric current excited by other means.

By the further improvement now about to be described, a magneto-electric machine is substituted for a voltaic battery for the purpose above mentioned, and the same may, under some circumstances, be a more convenient agent, as requiring comparatively little or no care and attention.

Figures 18, 19, 20, Sheet IV., is a magneto-electric machine, which may be of ordinary construction. W^1 is a temporary magnet of a similar description to the magnet W, hereinbefore described, and the same is fixed upon an axis *a* in suitable proximity to the permanent magnet W^2. Such being the position of the parts, it will follow, from the well-known laws of magneto-electricity, that while the temporary magnet W^1 is at rest with either of its poles opposite to either of the poles of the permanent magnet W^2, no electric current will be excited in the coils of wire round the temporary magnet W^1 by the proximity of that magnet to the permanent magnet W^2; but let the temporary magnet W^1 be moved by revolution of its axis, so as to change its said supposed position of parallelism to the permanent magnet W^2 into any other position relatively to such magnet, a momentary electric current will be excited in the coils round the temporary magnet W^1 (supposing them to be a complete metallic circuit) at the moment the change of position takes place, and the electric current so excited might be caused to excite momentary occasional magnetism in the magnet W, by which occasional magnetism so excited all the same effects would be produced, and all the same consequences would follow as would have followed from the excitement of a like continuation of occasional magnetism by an electric current excited by a voltaic battery. Such being the case, it is obvious that the descriptions hereinbefore contained in reference to figures 1, 2, 3, 4, sheet I., relative to the use of electro-magnetism for purposes of telegraphic communication, so far as the same may be applicable to the use of electro-magnetism of only momentary duration, are capable of being easily applied to the use of magneto-electricity for the same purpose, so that further descriptions in that respect are unnecessary. The difference between the use of electro-magnetism, as hereinbefore described, and that of magneto-electricity as now being described, consists, therefore, in the momentary duration of the latter as contrasted with the continuous action of the former. The practical effort of this difference is, that whereas by electro-magnet-

ism a distinct and available signal is obtained by each action, and one by each reaction of the escapement wheel, on the other hand by magneto-electricity an available signal is obtained by the reaction alone, because the action of the occasional magnetism upon the escapement wheel is merely momentary, and does not admit of the signal being prolonged for a sufficient time to be intelligible; consequently the revolving dial, hereinbefore described as giving twenty-four signals under the influence of electro-magnetism, would, if submitted to the influence of magneto-electricity, according to our present improvement, give only twelve signals. The above particulars being understood, it may easily be explained how magneto-electricity is made available as a means of exciting occasional magnetism, the occasional magnetism being, as already described, excited by a change of the position of the temporary magnet W^1 relatively to the permanent magnet W^2, it is obvious that, in the particular instrument now under description, such occasional magnetism must be excited primarily by means of the motion of the axis *a*, by which alone such relative position of the temporary magnet can be changed. For the purpose of acting upon the axis in a convenient manner, it is made to terminate in a small cog wheel *k* working into a large cog wheel, K. The large cog wheel may be considered as performing an office nearly similar to the communicator hereinbefore described, for it is divided into twelve equal parts by twelve pins projecting from one side of its rim, each pin representing one of the twelve signals which the apparatus is capable of giving, and being suitably marked accordingly. The cogs in the two wheels are so arranged that a motion of the large wheel, K, through one of its twelve divisions—that is to say, so that any one of its pins being at first opposite to any given point, the wheel is moved till the next pin becomes opposite to the same point—the axis of the temporary magnet will thereby be caused to perform half a revolution, so as by changing the relative position of the said temporary magnet, and consequently by exciting momentary occasional magnetism to give by reaction one signal as hereinbefore mentioned, and so also as to replace the temporary magnet in a suitable position for a repetition of the process. But inasmuch as the temporary magnet has performed only half and not an entire revolution, the position of its poles relatively to those of the permanent magnet has become reversed, consequently further mechanism is necessary for the purpose of causing the next electric current, which may be excited, as aforesaid, to flow in the same direc-

tion as before, and not in a contrary direction. This object is attained by interposing a disc, *p*, between the magnet W¹ and the small cog wheel *k*. A simple form of the disc might be a solid disc of brass or copper, containing merely a narrow strip of wood or other non-conducting material extending from side to side through its centre, so as to divide the whole disc into two solid semi-circular insulated pieces of metal, or else the disc may be (as shown in Figures 18, 19, 20), merely coated by plates of metal insulated from each other by an interposed piece of wood. Whichever form may be adopted, the end of one of the coils is to be fastened to one of the pieces or plates of metal, and the end of the other coil to the other piece, so that the ends of the two coils may be insulated from each other, and that the end of each may terminate in a distinct metallic piece or plate forming part of the said disc. The arrangement is such that whenever the two poles of the temporary magnet W¹ are placed in either direction opposite to the poles of the permanent magnet W², the two pieces or plates of metal of the disc *p*, and consequently the ends of the coils connected with them, as aforesaid, are respectively in necessary connection with the two springs *z z* (viz., one of such pieces or plates of metal with one spring and the other with the other spring), and the said springs with the buttons and wires belonging to and connected with them form one continuity of metal so as to combine the said coils and the continuation thereof into one metallic circuit capable of transmitting an electric current upon a change of the position of the temporary magnet W¹, as aforesaid. But when, by means hereinbefore described, the axis *a* is caused to perform half a revolution, as aforesaid, the same half revolution of the axis occasions also half a revolution of the disc *p*, and the arrangement is such that although at the end of such half revolution of the said disc the metallic pieces or plates thereof are still placed in such positions as to complete the continuity of the metallic circuit, nevertheless there is occasioned by such half revolution of the disc a reversal of the springs *z z*, with which the metallic pieces *a*, plates were before in contact; consequently, by the reversal of the springs the aforesaid reversal of the poles of the temporary magnet W¹ is neutralized, and the electric current is on every excitement thereof, as aforesaid, transmitted in the same direction from the springs *z z* into the wires communicating therewith. And it has already been explained that the exhibition of the characters which denote signals may be made by a movable index, or hand like the seconds' hand of a clock,

pointing to characters on a fixed dial, instead of a movable dial d, as represented in the apparatus, sheet I. A moving hand may be preferred as being lighter and more readily put in motion than a moving dial, but when a hand and fixed dial is used, the communicator shall be a counterpart thereof, having its character fixed in a circle with a movable index to point out them, instead of having its characters on a movable circle with a fixed index to point to them, as is represented in sheet I., and already described.

Sheet III., represents an apparatus for affecting the same purposes as that already described, but constructed with a movable hand to point to characters on a fixed dial, and with a communicator suitable for that mode of indicating the characters. And whereas it is proper for the person who is giving signals by aid of the communicator to keep his eye upon the dial of his own apparatus (whether it be a moving dial or a moving hand), in order to observe and keep watch whether the signals which he intends to give are all truly exhibited), and that his communicator and his dial concur truly in exhibiting the same characters, it will greatly facilitate such observing and watching of the progress of the dial or hand if the circular motion of the communicator is made concentric with and round about that of the dial or hand, which may be done by making the movable circle of the communicator a circular ring fitted to move around the circumference of the dial which occupies the interior of such ring. The apparatus represented in Sheet III. is constructed in that manner. And whereas it has been hereinbefore described that the resting position of the apparatus when no telegraphic communication is going on is a period of inaction of the occasional or temporary magnetism of the voltaic magnets, it should be understood that the same is not a necessary condition, for the apparatus may be constructed so as to remain at rest during the excitement of the occasional magnetism, which must in that case be kept steadily maintained during all the time of the intervals between making telegraphic communication by the apparatus. The apparatus represented in sheet III. is constructed in that manner. And, whereas, according to the description hereinbefore contained, although the attractive force attendant upon the excitement of occasional or temporary magnetism in the voltaic magnets is caused to produce the action requisite for giving signals, nevertheless that action is always followed by reaction by the force of a reacting weight or spring, which is overcome by the attractive force of the magnetism when the same is excited, but on the cessation of the magnetism then that reacting

force operates to give the next succeeding signal. It should be understood that the same is not a necessary condition, for the apparatus may be constructed to employ two voltaic magnets for exerting attractive force alternately, by exciting occasional magnetism first in one voltaic magnet and then in the other, in order that a piece of soft iron, situated between the two may be attracted and moved first one way by one magnet for giving one signal, and then the contrary way by the other magnet for giving the next succeeding signal, without any reacting spring. The apparatus represented in sheet III. is constructed to operate in that manner. It requires for that purpose to have three long conducting or telegraphic wires, 21, 22 and 23, whereof one wire, 21, extends by a direct course from one pole of the battery, at one terminal apparatus, to the contrary pole of the battery at the other terminal apparatus, without forming any coils around any of the voltaic magnets. The other two telegraphic wires, 22 and 23, extend from the two voltaic magnets in one terminal apparatus to the two voltaic magnets in the other terminal apparatus, that is, one of those two wires, 22, makes coils around the right-handmost voltaic magnet of each of the two terminal apparatuses, and the other of those two, 23, makes coils around the left-handmost voltaic magnet of each of the two terminal apparatuses. Both wires, 22 and 23, are occasionally coupled together at their two ends, and the coupled ends are connected with the poles of the batteries at the two terminal apparatuses, viz., to the contrary pole of each of those batteries to that pole thereof to which one end of the wire 21 is connected. The metallic circuit which is then formed includes all the three long telegraphic wires, 21, 22 and 23, and the electric current which is transmitted in one direction through that circuit is divided between the two coupled wires, 22 and 23, and occasional or temporary magnetism is then excited in all the voltaic magnets at the same time; but this is not always the case, for at other times, one or other of the two wires, 22 and 23, is disconnected at one or other of its ends (not both) from the batteries, and then that wire ceases to form part of the metallic circuit, and the voltaics magnet, around which that wire forms coils (being one of the two magnets in each apparatus), will cease to be excited, leaving the other of those two magnets excited. For instance, if the wire 23 is disconnected at one of its ends, leaving the fellow wire 22 connected at each of its ends with the two terminal batteries, then the electric current that is transmitted through the wire 22 will excite occasional magnetism in the right-handmost voltaic magnet of each of the ap-

paratuses, whereby the several pieces of soft iron in those apparatuses will all be attracted towards the right hand; but, on the contrary, if the wire 22 is disconnected at one of its ends, leaving the fellow wire 23 connected at each of its ends with the two terminal batteries, then the electric current that is transmitted through the wire 23 will excite occasional magnetism in the left-handmost voltaic magnet of each apparatus, whereby the several pieces of soft iron in those apparatuses will all be attracted towards the left hand. The conditions being premised, the construction of the apparatus, represented in sheet III., may be thus described: Figure 11 is a plan of one terminal apparatus, and figure 12 the other terminal apparatus; figure 13, being an intermediate apparatus, which, in order to simplify the description, may for the present be supposed not to exist, but that the two long telegraphic wires, 22 and 23, extend from figure 11 to figure 12, as is shown by the mere double lines without color, which pass over figure 13, without any connection with that figure. The two terminal apparatuses, figures 11 and 12, are exactly alike, although those two figures are drawn rather different, in order to explain interior or exterior parts; and figure 14 is a vertical section of both or either apparatus to show the interior mechanism. The wooden box or case of the apparatus is shaped somewhat like a small writing desk, for when the case I is placed on a table or horizontal plane, the upper side of the case forms an inclined plane or surface on which the revolving circular ring K of the communicator appears surrounding the fixed dial *c*, whereon the characters are marked, and to which the movable hand *d* points. A handle *q* is fixed to the revolving ring K, and projects upwards and onwards therefrom in a convenient manner for applying the hand or a finger thereto, in order to turn it around; and *s* is a small pointer which projects inwards from the handle *q*, in order to point to divisions which are marked around the fixed rim J, about which the ring K revolves as its centre of motion; and the same characters around the dial *c*, to which the hand *d* applies and points in order to indicate the signals, also serve for directing, by aid of the pointer *s*, where the handle *q* of the communicator K shall be turned to and stopped, in order to communicate each signal, and as the communicator K is turned steadily and deliberately round by its handle *q*, the hand *d* will be turned round at the same rate by the action of the occasional magnetism and the clock-work, so as to keep the point of the hand *d* always directed towards the pointer *s*, that is, provided that the ap-

paratus acts correctly; but if it does not, the fault cannot escape observation; the hand *d* will not be directed towards the pointer *s*, as it ought to be. The clock-work is contained in the box beneath the dial. A A (figure 14) are the plates of the frame of the clock-work; B, the spring barrel for the maintaining power, which acts by a cord or chain and fusee (which fusee does not appear in figure 14) and with a train of three wheels and three pinions to turn the axis *a* of the escapement wheel *b*, the end of which axis *a* passes through the dial plate *c*, and has the hand *d* fixed upon the extreme end of it. The pallets or anchor of the escapement is affixed to an axis *c* as their centre of motion, beyond which a lever arm projects out from the anchor (see figures 13 and 14), and the soft piece of iron V is affixed to the extremity of that lever arm in a proper position between the pole pieces *u*, *u* of the two voltaic magnets W, W, W, W, whereof one magnet is supported by a cross bar *n*, fixed at one side of the two clock plates *a*, *a*, and the other magnet to a like cross bar *n* at the other side. Those magnets are (or may be) the same as represented at figure 5, sheet I, and hereinbefore described. Each magnet consisting of two cylindrical pieces of soft iron, with a number of coils of wire around it, the two pieces so coiled being united together at one end of each by a connecting piece of iron *w*, and two such magnets being used; they are supported by screwing their respective connected pieces *w* to the supporting cross bar *n* of the frame. The pieces of iron *u*, *u*, which are fixed to the ends or poles of each of the magnets W, W, W, W, are opposite the other, leaving such space between them as is suitable for the reception of the piece of soft iron V of the escapement, and for the extent of motion which that piece of iron requires to have, in order that the escapement may act properly, to permit the teeth of the escapement wheel *b* to escape half a tooth a time, in the usual manner of clock escapements, excepting that the teeth of the escapement wheel *b*, and those parts of the pallets which act therewith are cut with a much greater slope in respect to each other than is usual in well-made clocks, in order that the effort which the maintaining power of the spring B exerts to turn the escapement wheel *b* round may operate to urge the pallets first one way and then the other with so much force as will keep them effectually in motion from right to left and back again from left to right alternately, without any chance of their resistance, when left to themselves, being ever able to stop the motion of the wheel *b*. But when occasional magnetism is excited in both the voltaic magnets, between which the piece of soft iron V is in-

cluded, the attractive force of that magnetism, although operating upon that piece V, at opposite sides thereof, will nevertheless act so much more powerfully on that one side of the piece V which is nearest the magnet on that side as to effectually detain the said piece V from moving, notwithstanding the tendency of the wheel *b* to move the same. For, as every magnet acts with a very great increase of attractive force upon a piece of iron which is so far very near to it as almost to touch over and above the attractive force of the same magnet can exert on the same piece of iron when it is removed to a small distance, it follows that when, by action of the escapement, the piece of iron V has been moved as far as it can go towards either of the voltaic magnets, for instance, the right-handmost (both being equally excited); it will then stand so very near to the pieces of iron *u*, *u*, at the poles of that right-handmost magnet, that although it does not actually touch them, nevertheless the attractive force of those pieces *u*, *u* will most completely overpower all the effort that the escapement can exert to move the piece V back again or towards the left hand, and that notwithstanding the other or left-handmost magnet is at the time exerting its attractive force upon the piece of iron V to draw it towards the left hand, because the said attractive force is so much lessened by the distance at which it acts upon the piece V, that, although acting in concert with the tendency of the escapement, it will not be able to move the piece V in opposition to the very much stronger force wherewith the other or right-handmost magnet, owing to its proximity, holds the piece V towards the right, wherefore the piece V will be effectually detained, and the escapement wheel *b*, together with the hand *d*, prevented from turning, but will stand motionless, pointing to the same character on the dial *c* so long as the excitement of both magnets is continued. And it is to be understood respecting the action of the apparatus, sheet III., so long as the spring B of clock-work continues wound up, that in all cases when the hand is so kept standing motionless, pointing to the character on the dial *c*, it will be when both magnets are excited with occasional or temporary magnetism at once, as above described, although when the hand is so resting it will be sometimes with the piece of iron V attracted or detained by action towards the right-hand voltaic magnet, and at other times towards the left-hand voltaic magnet. But whenever the said occasional magnetism of that voltaic magnet against or towards what the piece of iron V is so held attracted and detained (suppose, for instance, the right hand) ceases for a moment, then the said piece V, being no longer attracted

towards the right, will obey the influence of the escapement and allow the same to let one half tooth of the wheel *b* escape, so as to turn the hand round fron one character to the next, for that said influence causes the piece V to retreat to the left away from the said right hand-most voltaic magnet, against which it was before held and detained, and to approach very suddenly towards the opposite or left-hand-most voltaic magnet which does continue to be excited, and whereof the attractive force towards the left, although slight, acts in aid of the said influence of the escapement; but the united tendency of the said attractive force to the left, together with the tendency of the escapement was not sufficient to move the piece V towards the left away from the right-handmost voltaic magnet, to which it was near, until the magnetism thereof ceased. That cessation may be only momentary, and the same right-handmost voltaic magnet may be excited afresh, but it will not in consequence recall the piece of iron V back again towards it, notwithstanding that the escapement now tends to move it back to the right, because the left-handmost voltaic magnet now attracts the piece of iron V with the greatest force in consequence of the nearness thereof; and in detaining the piece V from moving will keep the escapement wheel and the hand standing still until the temporary magnetism of the left-handmost voltaic magnet is caused to cease for a moment, and then the piece V, being no longer attracted thereby, will move away therefrom towards the right and allow the escapement wheel *b* to turn another half tooth and turn the hand round to another character, and so on every time the occasional magnetism of either voltaic magnet is caused to cease for a moment the escapement wheel is allowed to move round half a tooth. And the requisite making and breaking of the circuit which will produce such momentary cessations of the occasional magnetism of first one voltaic magnet and then the other suitably for the above purpose, and which it is the office of the communicator to perform, may be thus explained: The revolving circle ring K has teeth around its circumference which act in those a small pinion, on the axis whereof a small circle or wheel *h* is fixed. The number of the teeth on the ring K exceeds those of the pinion as many times as there are teeth in the escapement wheel *b*; (in the present instance that is fifteen teeth, the dial being divided into that number, or thirty divisions and characters); hence the small circle *h* is caused to make one-half turn for each character. It has a piece of bone or wood fitted into a large notch in its circumference, and the rest of the circumference is metal, which metal is always

kept connected with the pole of the battery by a wire z^1. Two springs, 22z and 23z apply with their extremities in contact with opposite parts of the circumference of the circle h, and those springs are always in connection with the ends of the two long telegraphic wires 22 and 23, which as before mentioned, form coils around the several voltaic magnets, one wire around the right-handmost, and the other wire about the left-handmost of those magnets. As the circle h turns round one or other or else both of the springs 22z, 23z, form contact with the metal of that circumference, and thereby they connect one or other or else both the telegraphic wires 22 and 23 with the pole of the battery. The piece of bone in the said circumference applies sometimes to one spring 22z, sometimes to the other 23z, but never to both, wherefore sometimes one telegraph wire, 22, and at other times the other telegraph wire 23, becomes disconnected during a moment from the battery. The course of the several wires is so evident from the drawing as to require no further explanation. Whenever either apparatus is left standing still, and no telegraphic communication is making by it, then the handle q of that communicator K must be turned upwards, to point by its pointer s to the blank character on the dial as is the case in Figure 13, and then the circle h stands with the metal part of the circumference in contact with both the springs 22z, 23z, and consequently that end of both telegraphic wires 22 and 23 are connected with the pole of the battery at that terminus. The other apparatus, Figure 11, is represented in the act of giving a signal, the revolving circular ring K of its communicator being turned round by its handle q until its pointer s is directed to the character on the dial, which character may denote the conclusion of a word, and that the commencement of a succeeding word in the telegraphic communication is about to be given. The hand d points to the same character and so does also the hand of the other apparatus, Figure 13, and indicates to the person stationed at that apparatus that he is to note down that character as a signal given to him. The circle h in Figure 11 now presents the metal part of its circumference to the two springs 22z, 23z, and therefore that end of both telegraphic wires are connected with the battery at that terminus, and the opposite ends, Figure 13, of the same two wires, 22, 23, being also connected with the battery at that terminus, it follows that all the voltaic magnets (right hand as well as left hand) will be excited, and, as already explained, both terminal apparatuses, Figures 11 and 13, will detain their pieces of iron V and the pallets of

their escapements from allowing their respective escapement wheels *b* and hands *d* from moving. When a succeeding signal is to be given (suppose character letter G, for instance) then the handle *q* is to be moved steadily round until that handle and its pointer *s* gets round to point to that said letter G on the dial; and as the circle of the communicator K moves round the handle *d* will accompany it with a corresponding motion, and also the other *d*, Figure 11, will move at the same rate, so as always to point to the same characters one hand as the other. This advancing motion of the two hands step by step, alike is produced by momentary cessations of the excitement of magnetism in the several voltaic magnets alternately in the right-hand ones and in the left-hand ones, as already fully explained, that alternation being according as the piece of bone in the circumference of the revolving circle *h* is turned towards a left-hand spring 23*z*, or towards a righthand spring 22*z*, for to which ever side and spring that bone is for the time turned it will cause a momentary discontinuance of the excitement of the voltaic magnet on that same side; but that discontinuance is only momentary, because the handle *q* makes no stop in passing round from one character to another which is to be indicated, but is moved steadily round; and as the circle *h* then revolves quickly its piece of bone runs past the end of that spring, to which in turn it presents itself in an instant, and whenever the handle *q* and revolving circle K of the communicator is brought to rest it will be with its pointer *s* exactly over a division on the fixed circle J thereof, and with the pointer *s* opposite to a character on the dial, in which case the piece of bone will be either at the lower or else at the upper part of the circle *h*, out of the way of contact with either of the springs 22*z* or 23*z*, which will both be in contact with the metal of the circle *h*, and consequently both telegraphic wires 22 and 23 will be connected with the batteries, and all the voltaic magnets will be excited. And note, owing to the larger portion of the circumference of the circle *h* being metal and only a small portion thereof of bone, it follows that the contact of one spring with the metal will always take place before the other spring quits contact with the metal, by which means the re-excitement of the voltaic magnets on one side will always precede the discontinuance of the excitement of those on the other side, in order to insure that it shall never happen that neither are excited; for if that were to happen the piece of iron V would not be detained, but would allow the escapement wheel to move the pallets and the piece of iron V backwards and forwards

and turn around together with the hand; and at any time, if the apparatus is going decidedly wrong, that fault will be shown by the hand beginning to move round of itself. And as to sounding alarums, the clock-work for so doing is disposed in the same plates A A with the other clock-work, as is shown in figures 12 or 14, wherein S is the main-spring for the maintaining power of the alarum; H, its bell; *v*, its serrated wheel, which moves the hammer *y* for ringing that bell. O is the head of a slider, which, pushed in, catches the hammer to stop it from ringing, but when drawn out allows the hammer to act and sound the alarum whenever the ordinary stop detent of the alarum is disengaged, which is done by a pin or by pins in one of the wheels *j* of the clock-work, wherefore, in order to sound the alarum after preparation has been made by drawing out the head O, then the handle 2 of the communicator K being turned all round to allow the escapement wheel to turn round, that motion must bring one of the pins of the wheel *j* to the detent of the alarum, so as, by releasing that detent, to let off the alarum for sounding. But whenever that sounding is not desired the head O is pushed in. And note, if at any time the hand *d* gets wrong, so as not to correspond to the pointer *s*, the communicator K can be set right by turning it round in the backwards direction until the pointer *s* gets round opposite to the hand *d*, which will not move backwards. And as to the intermediate apparatus, figure 13, it is on the same construction as the two terminal apparatuses, figures 11 and 12, except in having two of the small revolving circles *h* and *h1* in place of one of such circles, and there is a spring 22*y*, 23*y*, to each of those circles. The telegraphic wires 22 and 23 take the course drawn and colored in sheet III., for connecting with the intermediate apparatus, figure 13. The spring 22*y* connects by a short wire with the left hand end of the coils around the right-handmost voltaic magnet, and the other spring 23*y* connects by a wire with the left hand of the coils around the left-handmost voltaic magnet. The telegraphic wire 22, from the terminal apparatus, figure 11, joins by the wire 22*n* to the right-hand end of the coils around the right-handmost voltaic magnet, and the other telegraphic wire 23, from the other terminal apparatus, figure 11, is connected by a wire 23*n* with the metal of the revolving circle *h*, and the telegraphic wire 22, from that other terminal apparatus, figure 12, connects by the branch 22*l* to the other revolving circle *h1;* also, the telegraphic wire 23, from the terminal apparatus, figure 12, connects by a branch with the revolving circle *h;* when thus connected the

intermediate apparatus, figure 13, is adapted to give signals by turning the handle *q* of its communicator K round, or, if that handle *q* is turned upwards, as in figure 13, and left standing there, the apparatus will be prepared for receiving signals in the same manner as either of the terminal apparatuses, figures 11 or 12, would do; but no battery is necessarily required for the intermediate apparatus, figure 13, the two batteries at the terminal apparatuses, figures 11 and 12, serving for the whole system shown in sheet III., or the same intermediate apparatus, figure 13, may also be used as a portable apparatus, to be connected with any part of the long line of the telegraphic wires 22, 23, where the means of connection have been provided, which, in the case of a road or a railway, may be at the mile posts. 40 represents the top of such a post. The wires 22, 23, are conducted up into two holes therein, where the continuity of each of those wires when in ordinary use is dependent upon the contact of two pairs of springs, 50, 51, 60, 61, which, by closing together, complete the metallic continuity of each of the two telegraphic wires 22 and 23; but whenever the portable apparatus, figure 13, is to be applied to the long telegraphic wires at such a mile post 40, its box or case is placed thereon in figure 13, and two wooden wedges, which project downward from that case, are inserted into the said holes in the top of that post 40, so as to enter between the two pairs of springs, 50, 51, and 60, 61, in order to wedge in between and separate the two springs of each pair one from the other, and thereby break the metallic continuity of each of the long telegraphic wires. But the said wedge pieces have a pair of metal plates applied to each side of each wedge, with wires 22*l*, 22*n*, 23*l*, 23*n*, ascending up into the apparatus from each metal plate; those plates having no metallic connection one with the other, but being in contact with the springs 50, 51, 60, 61, they, with their said ascending wires aforesaid, connect the parts of the apparatus with the long telegraphic wires in the manner as already described of figure 12, when considered as an intermediate apparatus. Figure 6, Sheet III., represents the escapement of the apparatus contained in that sheet on a large scale, to show how the pallets and the teeth of the escapement wheel *b* should be sloped in order to qualify them for performing in the manner already explained, and Figure W shows how two pieces of soft iron, V V, may be fixed to the pallets themselves in order to be attracted alternately in contrary directions by voltaic magnets, W, W and W, W, disposed at opposite sides of those pallets. Figure

H shows a different kind of escapement, which may be used in the apparatus contained in Sheet III., if the same were to be constructed in a simple manner without any spring barrel for maintaining power or train of wheel work to turn the escapement wheel *b* round together with the hand; but the force for that purpose must be wholly derived from the attractive force of the occasional magnetism; and the pallets are formed as represented, so that by being alternately moved one way and then the other, they will act on the teeth of the wheel *b* to turn it round. The piece or pieces of soft iron, which are to be operated upon by the said attractive force, may be applied either as represented in figure 12 or figure W. And for telegraphic communication between places which are too distant for an electric current to be transmitted all the way with sufficient vigor to be certain in its operation, a chain of such apparatuses as hereinbefore described must be established to communicate one to another through the whole distance, in which case what has been called the distant terminus of one apparatus will be situated close by the commencing terminus of the next apparatus, and the signals there received from one apparatus must be sent forward by the next apparatus, and so on, all which requires no explanation, because it is well known in the usual system of telegraphic communication, and forms no part of our present invention. And the same may be said of the telegraphic language or system of signals and their significations. Those systems which are well known and in use for other telegraphs may be used, or they may be modified, but they form no part of our invention.

Having now described our said improvements, I, the said Charles Wheatstone, for myself and for the said William Fothergill Cooke, do hereby declare that the new invention whereof the exclusive use is granted to us by the said letters patent of the twenty-first day of January, one thousand eight hundred and forty, consists in the following particulars: And note, whereas the particulars of improvements which were claimed by me and William Fothergill Cooke in the former specification, by virtue of our patent of the twelfth day of June, one thousand eight hundred and thirty-seven, were therein enumerated as "firstly," "secondly," and so in due order up to "ninthly;" and also whereas the several particulars of improvements claimed by the said William Fothergill Cooke in another specification, by virtue of letters patent granted to him on the eighteenth day of April, one thousand eight hundred and thirty-eight, were therein enumerated as Part A, Part B and so on in due

order up to Part F, I shall, in order to avoid confusion therewith, enumerate the several particulars of improvements which we, Charles Wheatstone and William Fothergill Cooke, now claim in the specification by virtue of our said letters patent of the twenty-first of January, one thousand eight hundred and forty, under the heads or titles Part G, Part H, and so on as follows, and represented in figures 4 to 5, Sheet I., and figures 11, 12 and 13.

Part G is the improvement, hereinbefore fully described, of employing the attractive force of occasional or temporary magnetism which is excited in soft iron by means of electric currents transmitted through metallic circuits, for the purpose, by alternately exciting and ceasing to excite such magnetism, of producing, by intervention of suitable mechanism such as hereinbefore described (but the construction of which mechanism may be greatly varied), and such motion of a hand or other indicator for pointing to characters on a fixed dial as will qualify that hand or indicator for exhibiting those characters in a suitable manner for giving signals, or of producing such motion of a dial with characters thereon as will qualify that dial for exhibiting those characters in a suitable manner for giving signals, or employing the said attractive forces for the purpose of governing, directing and controlling, by the intervention of suitable mechanism, such as hereinbefore described (but the construction of which mechanism may be greatly varied), the motion, as aforesaid, such hand or other indicator, or of such dial, when the force or power requisite for producing that motion is derived from or is assisted by action of an independent maintaining power, so that the motion is only directed, governed, or controlled by the said attractive force of occasional or temporary magnetism, and that whether the aforesaid electric currents are excited by means of voltaic batteries, or any kind of magneto-electric or other machine or apparatus capable of producing such currents.

Part H. is the improvement, hereinbefore described, of the mechanism, which we have called a communicator, for alternately making and breaking any such metallic surface as is suitable for the transmission of electric currents in spiral convolutions around masses of soft iron, so as to excite occasional or temporary or voltaic megnetism in such masses whenever the said circuit is made and cessation of that magnetism whenever the said circiut is broken, in order by such alternate making and breaking of the circuit in rapid succession (without necessity for pause) as many times in succession as is required to obtain alternate excitement and cessation

2363

of the said magnetism, for the purpose of producing (according to the preceding part G of our improvements) motion of hand or a dial, or else of regulating such motion as is stated in the said preceding Part G.

Part I is the improvement, hereinbefore described, and represented at figure Sheet IV., of the drawings hereunto annexed, for sounding alarums in distant places by aid of machinery, which is kept in continual motion by any suitable maintaining power, that motion being kept regulated as to speed by any suitable kind of regulator, and which machinery at regular intervals, by raising a hammer or other like means, strikes with sufficient force for releasing the detaining detent of the wheel work through its alarum, provided that the blow was struck on that detent, but which it is prevented by some suitable stop from doing, unless the end of a magnetic needle is interposed between such detent and the hammer, so as to transmit the blow thereof to the detent and release the same in order to sound the alarum, such interposition of the end of that magnetic needle resulting from its angular motion caused by the transmission of an electric current through multiplying coils of conducting wire surrounding the space wherein such needle is contained; or, in lieu of a magnetic needle to be moved with angular motion by an electric current for the purpose of so interposing a solid body between the hammer and the detent, as aforesaid, the requisite motion for interposing may be derived from the attractive force of occasional magnetism excited in a voltaic magnet, by an electric current, and acting on a piece of iron connected in any suitable manner with the solid body which is to be interposed by such occasional magnetism.

Part J. is the improvement hereinbefore described, and represented in figure 22, sheet II., where by the angular motions which may be given by electric currents to magnetic needles, which are movable in spaces surrounded by multiplying coils of wire, forming metallic circuits through which such electric currents are transmitted is caused to give motion by the intervention of suitable mechanism to a hand or dial for exhibiting characters in a suitable manner for given signals.

Part K is the improvement hereinbefore described, and represented in figures 18, 19 and 20, sheet IV., for employing the attractive force of occasional or temporary magnetism which will be excited in soft iron by transmission of electric currents through metallic circuits for the purpose, by action of such attractive force

2264

on suitable mechanism, of sounding alarums, when such electric currents are produced by magneto-electric apparatus instead of by voltaic batteries.

Part L is the improvement hereinbefore described and represented in figures 11, 12 and 13, sheet III., whereby the revolving apparatus which we call a communicator (as stated and claimed in Part H) is rendered concentric with the dial or hand whereby the characters are exhibited, the revolving motion of such concentric communicator being coincident with that of the hand or dial when exhibiting characters.

Part M is the improvement hereinbefore described, and represented in figures 11, 12 and 13, sheet III., whereby one of the long telegraphic wires being appropriated to the voltaic batteries by which electric currents are to be produced, and two other long telegraphic wires being provided to transmit the current in one direction (but the current divided between those two), the same battery is enabled to serve apparatuses at great distances asunder without necessity for employing a battery at each apparatus, and therefore a portable apparatus may be applied to any part of the length of the telegraphic wires, as shown by figure 12, without the inconvenience of carrying a battery therewith.

Part N is the improvement hereinbefore described, and represented in figures 11, 12 and 13, sheet III., whereby the rest of cessation of motion in the hands or dials, by which characters are exhibited, is derived from the continued transmission of an electric current through the metallic circuit, which extends throughout the whole system of apparatuses; and also whereby momentary cessations of such current through one or other of the two wires, both of which usually transmit the current in one direction (but the current divided between those two), such momentary cessations are made to produce, by intervention of suitable mechanism, motions of a hand or dial and other parts adequate for the purposes of exhibiting signals and sounding alarums.

In witness whereof I, the said Charles Wheatstone, have hereunto set my hand and seal, this twenty-first day of July, one thousand eight-hundred and forty.

CHARLES [L. S.] WHEATSTONE.

2265

And be it remembered, that on the twenty-first day of July, in the third year of the reign of her Majesty Queen Victoria, the said Charles Wheatstone came before our said Lady the Queen, in her Chancery, and acknowledged the instrument aforesaid, and all and every thing therein contained and specified in form above written. And also the instrument aforesaid was stamped according to the tenor of the statute made in the fifty-fifth year of the reign of His Late Majesty King George the Third.

Inrolled the twenty-first day of July one thousand eight hundred and forty.

n266

(No. 50.) Defendants' Exhibit, "Gray's Organ Pipe Transmitter Patent."

J. A. W., Ex'r.

[Introduced in Record, p. 11.]

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN AUTOMATIC CIRCUIT-BREAKERS FOR ELECTRO HARMONIC TELEGRAPHS.

Specification forming a part of Letters Patent No. 173,460, dated February 15, 1876. Application filed January 8, 1876.

To all whom it may concern:

Be it known that I, ELISHA GRAY, of Chicago, in the County of Cook, and State of Illinois, have invented a new and useful improvement in automatic circuit-breakers for electro-harmonic telegraphs, of which the following is a specification:

My invention relates to electro-harmonic telegraphs of the class secured to me by Letters Patent of the United States, numbered respectively 176,095 and 166,096, granted July 27, 1875. Its object is to produce a simple and effective circuit-breaker, vibrating automatically with sufficient rapidity to produce a musical tone of a given pitch, the electrical impulses thus generated being transmitted through an electric circuit and reproduced at the other end of the line, as set forth in my patents above mentioned, to which end my improvement consists in combining with an organ or other wind-pipe, a diaphragm vibrated by sounding said pipe, and an electric circuit connected with said diaphragm so as to be opened and closed by its vibrations.

In the accompanying drawings, which exemplify one of the best ways now known to me of carrying out the objects of my invention. Figure 1 represents a plan view of my improved apparatus; Fig. 2 a side view, and Fig. 3 a longitudinal, vertical section there through on the line of Fig.

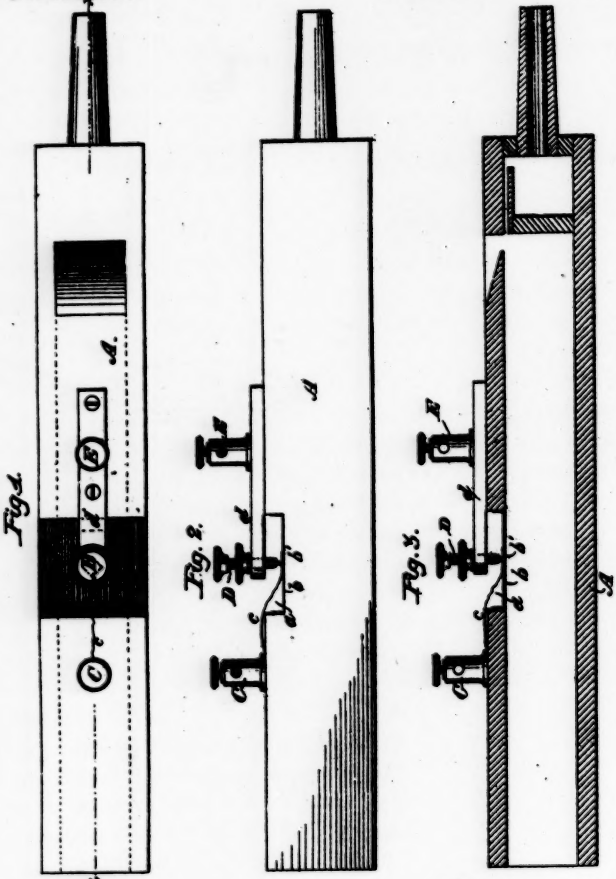
An organ-pipe, A, is shown as made with an opening *a*, in its side, over which a membranous diaphragm *b*, is stretched. One wire of the circuit is connected with a binding post, C, from which a wire,

2267

E. GRAY.

AUTOMATIC CIRCUIT-BREAKERS FOR ELECTRO-HARMONIC TELEGRAPHS.

No. 173,460. Patented Feb. 15, 1876.



Witnesses
Baltis & Long
F. Stahl

Inventor.
ELISHA GRAY

BY HIS ATTORNEY
W. J. Baldwin

2268

c, leads to a platina point, *b'*, on the diaphragm underneath a set screw, D, mounted on a bar or frame, *d*, connected with a binding post, E, to which the other wire of the circuit is attached.

When the column of air in the pipe is vibrated by sounding the pipe the diaphragm will vibrate correspondingly with the musical tone thus produced, and open and close the circuit accordingly, thus transmitting the vibrations to the receiving instrument for utilization, as mentioned in my patents before referred to.

Obviously the vibrations of several pipes giving notes of different pitch may be simultaneously transmitted through a single wire by suitable mechanism.

I claim :

The combination, substantially as hereinbefore set forth, of an organ-pipe, a membranous diaphragm vibrated by sounding said pipe, and an electric circuit opened and closed by said vibrations.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses :

ENOS M. BARTON,
GEO. H. BLISS.

(No. 51.) Defendants' Exhibit, Gray's Reed Transmitter.

J. A. W., Ex'r.

[Introduced in Record, p. 12.]

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN TRANSMITTERS FOR ELECTRO-HARMONIC TELEGRAPHS.

Specifications forming part of Letters Patent No. 165,728, dated July 20, 1875; application filed June 28, 1875.

To all whom it may concern:

Be it known that I, ELISHA GRAY, of Chicago, in the County of Cook and State of Illinois, have invented certain new and useful Improvements in transmitters for Electro-Harmonic Telegraphs, of which the following is a specification:

My invention relates to telegraphic apparatus of that class in which a circuit-breaking spring is automatically vibrated with sufficient rapidity to produce a musical tone.

In such instruments as heretofore constructed, so far as my knowledge extends, electro-magnets, by which the spring is attracted have always been placed on one side of the vibrating bar or electrotome by which the musical note was produced. A tendency has consequently existed toward the disturbance of its vibrations.

The object of my invention is to remedy this defect; to which end my improvements consist in arranging upon opposite sides of the vibrating springs of the electrotome, electro-magnets of such relative power as to impart impulses of equal force upon each side of the vibrating spring alternately at equal intervals, thus securing its isochronous vibration. My invention further consists in

2270

E. GRAY.

Transmitter for Electro-Harmonic Telegraph.

No. 165,728. Patented July 20, 1875.

Fig. 1.

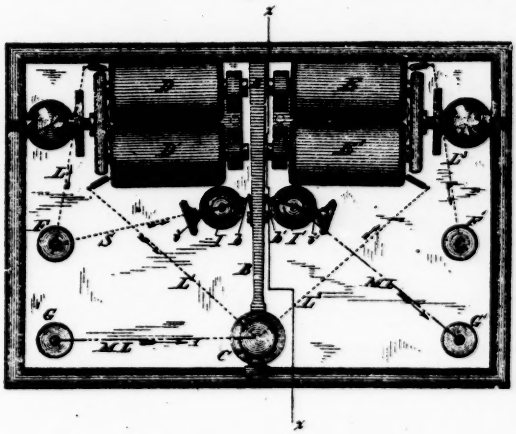
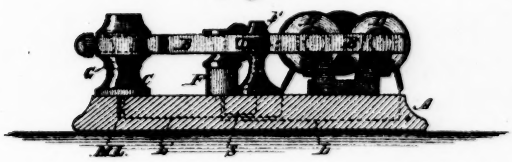


Fig. 2.



WITNESSES

Harry King
Edwardson

Elisha Gray INVENTOR.

By his Attorney

Wm D. Baldwin

combining, with the magnets and vibrating spring or reed, shunting wires so arranged as automatically to transfer the current from one magnet to the other without the use of a switch.

In the accompanying drawings, which show so much of my improved apparatus as is necessary to illustrate the subject-matter herein claimed, Figure 1 is a plan or top view, and Fig. 2, a vertical transverse section there through, on the line *x x*, Fig. 1.

The apparatus is mounted upon an ordinary base-board, A. A steel-bar spring or vibrating reed, B, tuned to give a musical tone of a given pitch when thrown into vibration is secured by one end to a post, C, while its free end extends between two pairs of magnets, D D′ E E′, arranged transversely to the reeds in the plane of its vibration, their poles being arranged just far enough apart to accommodate this vibratory movement. F F′ G G′ are binding screws to which the main and local battery wires are respectively connected. The magnets D D′ are wound with a resistance of about sixteen ohms or units of resistance, while magnets E E′ have only a resistance of about four ohms.

It is a well-known fact that when two magnets of different resistances, other things being equal, are placed in the same circuit and a battery-current sent through them, the magnet having the higher resistance develops the stronger magnetism, which magnetism is stronger in proportion as the resistance is higher than that of the other magnet. In other words, if the magnet E E′, when alone in the circuit, have a power, say, of four, their effect will be diminished to a power of one when magnets D D′ are let in, and the power of the letter will rise from zero to five.

The reed B is provided with spring contact-points *b b′*, arranged one on each side thereof, intermediate between the magnets and its supporting post. When the reed is at rest these points are in contact with adjusting screws *i i*, of binding posts I I′. Fig. 1 shows the battery connections. The main line M L extends from the binding screw G through the wrie 1 to the reed supporting post C; thence through the reed and its contact point *b′* to the binding screw I′; thence to the binding screw G′. The local circuit passes from the battery through the binding post F by the wire L to the magnets D D′; thence by the wire L^1 through the reed supporting post C, and the wire L^2 to the magnets E E′; thence by the wire L^3 to the binding F′. In addition to this a shunt wire S passes from the binding post F to the post I, through the contact point *b* to the reed and its supporting post C, where it connects with the local circuit L L^2.

The operation of the apparatus is as follows:

When the local circuit is established the current does not pass through the magnets D D′ by the wire L, as it finds an easier passage through the shunt wire S and contact point *b*, vibrating reed B, posts C, and wire L^2, to the magnets E E′; thence by the wire L^3, to the other pole of the local battery. The passage of this current develops in the latter magnet the power, say, of four, which is exerted upon the vibrating reed B. and draws it toward the poles of the magnet. When the reed is moved a short distance in obedience to this impulse, its movement causes the contact point *b* to separate from the binding screw *i*, when, of course, the current will no longer flow through the shunt wire S, but passes from the post F through the wire L directly to the magnets D D′, and from thence through the wires L^1 L^2, to the magnets E E′; thence through the wire L^3 to the post F′, which connects with the other pole of the local battery. This raises the power of the magnets D D′ from zero to a power of five, while the other magnets drop fom four to one. The result is, that the reed vibrates back towards the magnets D D′ with the same force that it did toward the other magnets—that is, a power of four each way. When the points *b i* come in contact again the magnets D D′ are cut out of the circuit by the establishment of the current through the shunt wire S, and their power drops to zero, and the operation above described is repeated. This alternate opening and closing of the circuit takes place with a frequency equal to the rate per second sufficient to produce the fundamental tone of the vibrating reed. The main line current is interrupted at every vibration of the reed by the separation of the contact points *b i*′, consequently a series of impulses corresponding in number with the said vibrations, will be transmitted to a suitable receiver and reproduced in a tone of corresponding pitch to that of the vibrating reed, as fully explained in sundry applications for Letters Patent of the United States, for apparatus for transmitting musical impressions or sounds telegraphically, heretofore filed by me.

The advantages of my improvement are, that the impulses imparted to the vibrating reed being alike on both sides, its centre of vibration coincides with the axis of the reed when at rest. The isochronous vibration of the reed is thus preserved in its integrity, and, consequently, that of the electric waves or impulses generated by it, which are transmitied through the main line, which impulses determine those of the receiver, and the vibrating reed is prevented from being thrown out of tune with the receiver of variations in the

222/3

battery power, which variations are liable to occur in the ordinary method.

I claim—

1. The combination, substantially as hereinbefore set forth, of the vibrating electrotome and magnets arranged on opposite sides thereof, of such relative capacity as to impart impulses of equal force at intervals upon each side of the vibrating electrotome alternately, whereby its isochronous vibration is secured.

2. The combination, substantially as hereinbefore set forth, of the vibrating reed, its counter-poise magnets, a local circuit, and the shunt wire, whereby the current is automatically changed to each set of magnets.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

WM. J. PEYTON,

E. C. DAVIDSON.

(No. 52) Defendants' Exhibit, Lockwood & Bartlett's Patent for Transmitter for Telephones.

J. A. Welch, Special Examiner, May 14, 1884.

[Introduced in Record, p. 12.]

UNITED STATES PATENT OFFICE.

ROBERT M. LOCKWOOD AND SAMUEL H. BARTLETT, OF NEW YORK, N. Y. ASSIGNORS OF ONE-HALF OF THEIR RIGHT TO CHARLES F. LIVERMORE, OF THE SAME PLACE.

TRANSMITTER FOR TELEPHONES.

Specification forming part of Letters Patent No. 228,824, dated June 15th, 1880. Application filed March 9, 1880 (No model).

To all whom it may concern:

Be it known that we, Robert M. Lockwood and Samuel H. Bartlett, both of the City, County and State of New York, have invented certain new and useful improvements in transmitters for telephones or Vocal Telegraphs, of which the following is a full, clear and exact description, reference being had to the accompanying drawing, which represents our improved transmitter in section.

In the telephones as heretofore constructed the transmitting instrument, or that which received the sound waves and transmits them to the electrically-charged conductors, has been organized upon the theory of mechanical vibration due to the action of the sound waves, and from this has arisen the device of a thin flexible metallic diaphragm, the vibrations of which were transmitted by the electric current to the receiver; and all telephones in what may be termed successful operation in one form or another, so far as we are acquainted with them, employ this so-called "mechanical vibration." We propose to dispense with this mechanical vibration, and as a substitute therefor we employ what we term "molecular" disturbance or vibration, the construction of our apparatus being such as to prevent, as far as practicable, anything in the nature of mechanical vibration. This feature was partially developed in an

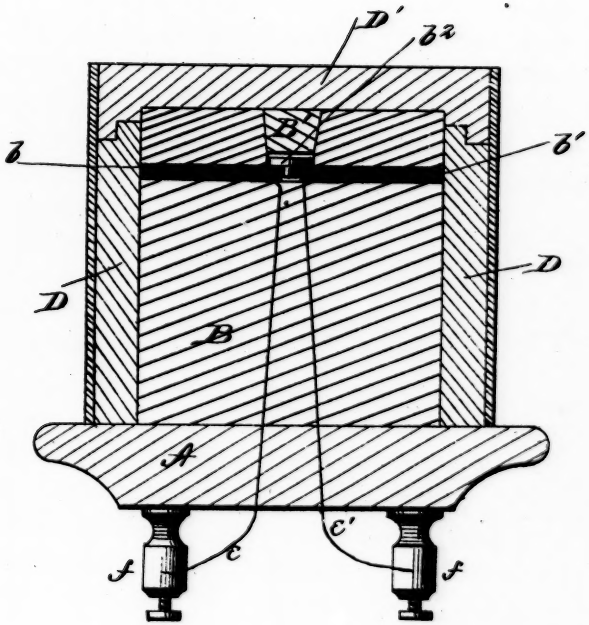
(No Model.)

2275

R. M. LOCKWOOD & S. H. BARTLETT.

Transmitter for Telephones.

No. 228,824. **Patented June 15, 1880.**



application for letters patent filed by us Nov. 3, 1879, but in that the carbon plates, while supported by the non-resonant material, were left uncovered at their inner adjacent ends, and sound chambers were formed in the non-resonant block on opposite sides, thereof, one of which communicated with the external atmosphere, rendering the plates and the connecting button liable to be more or less affected or mechanically disturbed by the direct action of the sound waves. In the present instance we embed the carbon or conducting plates solidly throughout their entire length in and cover or surround said plates and the button with the non-resonant material, as hereinafter explained.

In the accompanying drawing, A represents a base plate of wood, upon which is secured a block or cylinder, B, of cork or other suitable non-resonant material. Near the upper end of this block two bars or plates of carbon, *bb*, or other suitable conductors of electricity, are secured by being solidly embedded in the cork, as shown. These bars are arranged transversely of the block, extending from near its centre to or nearly to its outer face, on opposite sides as shown. Between the inner adjacent ends of these bars is placed a headed pin of carbon or other suitable conducting material similar to that of which the bars are composed, the head of said pin constituting what we term a "button," which connects the two plates and rests upon the adjacent ends of the bars by its own gravity. A cavity is formed in the block B directly over this button, to give access to it for removing or replacing it, and this cavity, when the button is in place, is closed by a plug B′, of similar material to that of which the body of the block is formed, and which rests in close proximity with and prevents accidental displacement of the button. The block B thus formed, with the carbon bars embedded within it, is by preference fitted snugly in a metal cylinder D, the open end of which rests against the base plate A, the other end being covered by a metal cup or cover D′, screwed upon or otherwise firmly secured thereto, and the metal case is in turn covered with leather, rubber, canton-flannel, or other soft non-resonant material, as shown but the metal cylinder and its covering may be dispensed with.

Wires *e e*, are connected with the carbon plates *b b*, one to each, and extend thence out through the body B of the block

in any convenient direction, and are connected at their outer ends to screw posts *f f* on the base plate A. The main-line wires connected with the battery are also connected with these screw posts in the same manner as in an ordinary telegraph instrument, and as will be seen, the wires *e e*, carbon plates *b b*, and button *b*2 serve to connect said main line wires and thereby complete the circuit.

The sound waves in speaking, &c., are received upon the face or sides of the block of non-resonant material, or upon its covering described, and are communicated through said block and the carbon plates to the button *b*2 and through what we term a "molecular disturbance" the action or disturbance of the latter is communicated through the plates to the electrically charged wires *e e*, which complete the battery circuit, and thence over the main line wires to the point connected therewith. We thus make use of the direct current from the battery in the transmission of the sound-waves, and are thus enabled to transmit them like distances and with the same precision as an ordinary telegraphic message is transmitted

As will be seen, our construction of the transmitter is such as is calculated to, and we believe it does as far as practicable, obviate all so called "mechanical vibration" of the parts, for the carbon or conducting bars or plates being solidly cushioned or embedded in some firm non-resonant substance, (such as cork) the disturbance caused must be other than mechanical and constitutes what we call "molecular" disturbance.

The means for repeating or transmitting the vocal sounds over long lines or a series of circuits and for receiving the same are embraced in other applications filed herewith, and need not therefore be here described.

Having now described our invention, we claim—

1. In a transmitter for telephones or vocal sound telegraphs, a block of non-resonant substance provided with strips or plates of carbon or other conducting material embedded in it, for

2. The block of non-resonant material having conductors embedded within it, and wires extending therefrom for connecting with the main line current, substantially as described.

3. The non-resonant block in which the carbon plates are embedded, in combination with the enclosing metallic case or cylinder, substantially as described.

2278

4. The combination of the non-resonant block B, enclosing metal case D, and flexible cover thereto, substantially as described.

ROBT. M. LOCKWOOD,
SAMUEL H. BARTLETT.

Witnesses :
F. L. OURAND,
ALEX. MAHON.

2219

(No. 53.) Defendants' Exhibit, Lockwood & Bartlett.

J. A. Welch, Sp. Exr., May 14, '84.

[Introduced in Record, p. 12.]

UNITED STATES PATENT OFFICE.

ROBERT M. LOCKWOOD AND SAMUEL H. BARTLETT, OF NEW YORK, N. Y., ASSIGNORS OF ONE-HALF OF THEIR RIGHT TO CHARLES F. LIVERMORE, OF SAME PLACE.

TELEPHONE RECEIVER.

Specification forming part of Letters Patent No. 228,825, dated June 15th, 1880. Application filed April 30, 1880. (No model.)

To all whom it may concern:

Be it known that we, Robert M. Lockwood and Samuel H. Bartlett, of the City, County and State of New York, have invented a new and useful Improvement in Telephone Receivers, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, making part of this specification, in which—

Figure 1 represents our improved telephone or vocal sound telegraph receiver. Fig. 2 is a similar view, showing a modification in the manner of connecting the diaphragm with the magnet. Fig. 3 G is an end view of the construction shown in Fig. 2, with the ear piece and diaphragm removed and Figs. 4 and 5 are prospective views of the end of the magnet, having one the spring arm and the other the spring arm and diaphragm applied.

Similar letters of reference denote corresponding parts whenever used.

Our invention relates to a novel construction of the end of the magnet to which the diaphragm is connected, whereby through disturbance or variations of magnetic power between parts of the same pole of the magnet, vocal sounds are transmitted to the diaphragm or sounding board; and it consists in extending the pole in the form of a flat U-shaped spring, the

(No Model.)

R. M. LOCKWOOD & S. H.

Telephone Receiv

No. 228,825. Pat

Fig. 1.

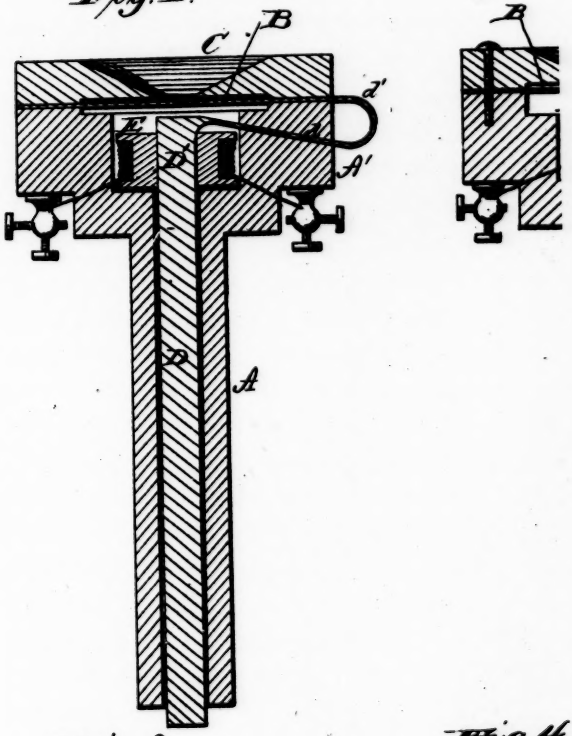


Fig. 3.

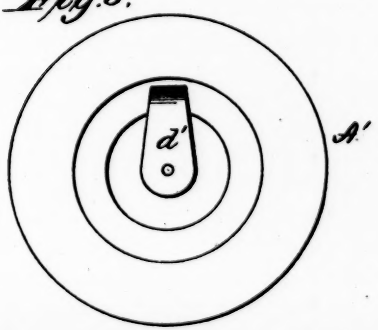


Fig. 4.

Witnesses.
F. L. Ouvaud
Alex Mahon

(No. 53.) Defendants' Exhibit, Lockwood & Bartlett.

J. A. Welch, Sp. Exr., May 14, '84.

[Introduced in Record, p. 12.]

UNITED STATES PATENT OFFICE.

ROBERT M. LOCKWOOD AND SAMUEL H. BARTLETT, OF NEW YORK, N. Y., ASSIGNORS OF ONE-HALF OF THEIR RIGHT TO CHARLES F. LIVERMORE, OF SAME PLACE.

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Figure 1 represents our improved telephone or vocal sound telegraph receiver. Fig. 2 is a similar view, showing a modification in the manner of connecting the diaphragm with the magnet. Fig. 3 G is an end view of the construction shown in Fig. 2, with the ear piece and diaphragm removed and Figs. 4 and 5 are prospective views of the end of the magnet, having one the spring arm and the other the spring arm and diaphragm applied.

Similar letters of reference denote corresponding parts whenever used.

Our invention relates to a novel construction of the end of the magnet to which the diaphragm is connected, whereby through disturbance or variations of magnetic power between parts of the same pole of the magnet, vocal sounds are transmitted to the diaphragm or sounding board; and it consists in extending the pole in the form of a flat U-shaped spring, the

(No Model.)

R. M. LOCKWOOD & S. H. BARTLETT.

Telephone Receiver.

No. 228,825. Patented June 15, 1880.

Fig. 1.

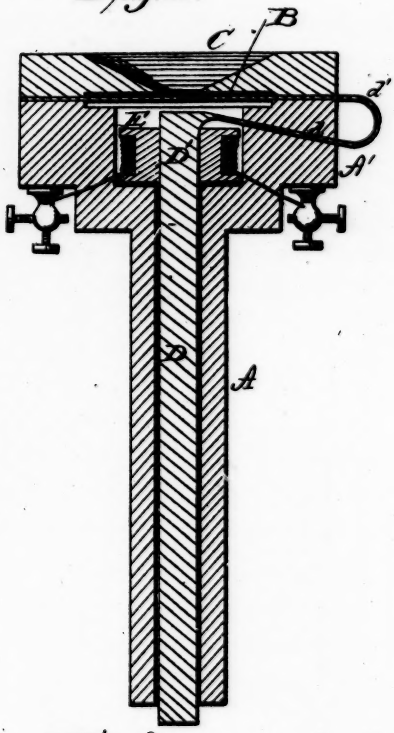


Fig. 2.

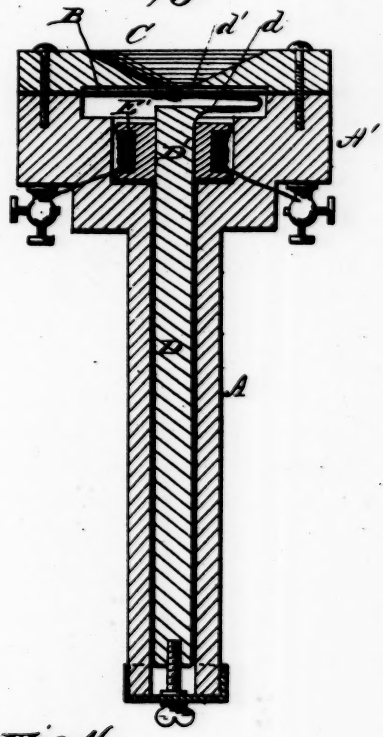


Fig. 3.

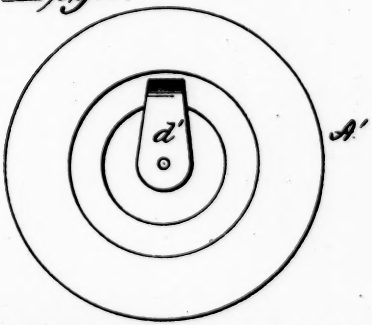
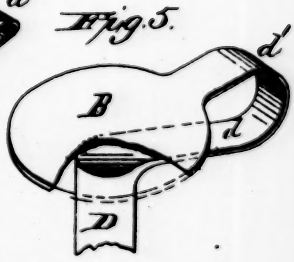


Fig. 4.

Fig. 5.



Witnesses.
F. L. Ousand
Alex. Mahon

Inventors.
Robt. M. Lockwood.
Saml. H. Bartlett,
by A. M. Smith & Atty.

outer free end of which overhanging the end of the magnet of which it is an extension is expanded into or has the diaphragm connected with it, as hereinafter explained.

In the accompanying drawings, A represents the body or handle of the receiver, made of wood or other suitable material, cylindrical in form, and enlarged at one end, A′, to accomdate the diaphragm B and ear-piece C secured thereto.

The body or handle A is perforated longitudinally to receive the magnet D, the perforation in the enlarged end A′ being enlarged into a socket for *a*, the reception of a spool or helix, E, surrounding the end D′ of the magnet as shown. The magnet at the end D′ is drawn out, reduced in size, and bent at a right angle to the body D of the magnet, or nearly so, extends to one side thereof in the form of a flat spring, *d*, recurved upon itself in U form until the outer arm or end, *d′*, overhangs the end D′ of the body of the magnet, as shown.

Where the end *d′* is expanded to form the diaphragm B, as shown, the spring portion passes out through an opening in the head A′, and is there recurved so as to bring the diaphragm over the end thereof, where it is held in place by the ear-piece C, which is secured to said head or end by screws or other suitable fastening devices; but as good practical results have been obtained by making the diaphragm of different materials from the magnet, such as wood, paper, parchment, brass, &c., constituting a sounding-board, the end *d′* of the spring arm may terminate at a point overhanging the end D′ of the body of the magnet, and the diaphragm or sounding-board may be bolted or otherwise firmly fastened to it, as shown in Fig. 2. Where the latter form of construction is employed the magnet should be made adjustable longitudinally by means of a thumb-screw or equivalent device, as shown, for adjusting the tension of the disk or sounding-board B as may be necessary to give it the utmost efficiency.

Under the arrangement described it will be seen that the spring arm *d d′* forms an extension of the pole D′ of the magnet, reduced in size, and its normal condition will be one of rest in relation thereto. Thus calling the current in the helix E one, the amount of magnetism in the magnet D at D′ will be one and that in the arm *d′* one, and the latter will be at rest. The body of the magnet lies within the helix, and is more easily and quickly effected by it, and constitutes, as it were, a reser-

voir from which the smaller arm *d d'* is supplied. Now, supposing the current in the helix to be suddenly increased to two, the end D' becomes two in advance of the end *d'*, and for the instant attracts the latter until it becomes also two, when it again instantly repels it; then its normal condition as a part of the same pole is restored, and it returns to its position of rest, until again attracted or repelled through another disturbance of the current in the helix. Thus for each disturbance in the current there will be three distinct movements of the arm *d'* or diaphragm B connected therewith. First, it will be drawn down or toward the end D', then it will be repelled beyond its normal position, and finally, the equilibrium being restored, it moves back to rest. Thus it will be seen that the diaphragm is operated by differences or disturbances of degree of polarity or attraction and repulsion in the same pole.

In Fig. 4 the magnet is shown made up of a number of strips, an extension of one of which forms the spring arm. This form obviates the necessity of drawing out the body of the magnet and facilitates its construction.

We are aware that the pole or poles of a horseshoe magnet have been expanded to form a disk or diaphragm; but in such cases, so far as we are advised, the diaphragm has been brought into such relation to the opposite pole of the magnet as to be acted upon and controlled or held under restraint by said pole by intercharge of polarity. This we do not claim; but,

Having now described our invention, we claim—

1. The pole of the magnet extended in the form of a laterally-projecting recurved arm and connected with the diaphragm or sounding-board substantially as described.

2. The curved spring and diaphragm, made in one piece with and forming an extension of the pole of the magnet, substantially as described.

3. The diaphragm connected with the magnet through the spring-extension of one pole of the latter and arranged with relation to said pole substantially as shown and described.

In testimony whereof, we have hereunto set our hands this 29th day of April, A. D. 1880.

ROBERT M. LOCKWOOD.
SAMUEL H. BARTLETT.

Witnesses:
C. H. HANKINSON.
T. W. HARTFIELD.

(No. 54) Defendants' Exhibit, "Deposition of William M. Goodridge." (Introduced by Defendants in this cause, from Printed Record, Bell Telephone Company et al. vs. Peter A. Dowd, pp. 68–110.)

J. A. W., Sp. Ex'r.

[Introduced in Record, p. 12.]

DIRECT EXAMINATION BY CAUSTEN BROWNE, ESQ., OF COUNSEL FOR DEFENDANT:

Int. 1. What is your name, age, residence and occupation?

Ans. William M. Goodridge; I am forty-three years old; I reside at Highland Park, Illinois, and am assistant to Mr. Elisha Gray in the development of his electrical inventions.

Int. 2. When did you begin to be so employed by Mr. Gray?

Ans. In the early part of the year 1874.

Int. 3. In what month of 1874, if you can state, did you begin to be exclusively employed in the manner you have stated?

Ans. May; in the month of May.

Int. 4. In what employment were you just before that?

Ans. In the employ of the Western Electric Manufacturing Company, of Chicago, Illinois.

Int. 5. What relation, if any, was Mr. Gray at that time sustaining to that company?

Ans. He was the superintendent.

Int. 6. In the course of your employment by Mr. Gray have you had occasion to make or assist in or superintend the making of different instruments for the electrical transmission of musical tones?

Ans. I have.

Int. 7. Did you do any such work for Mr. Gray before you became exclusively employed by him, which you say was in May, 1874?

Ans. I did.

Int. 8. Will you state what that work was? And if the instrument then made is shown in the drawing of any patent or represented by any model you have here, will you please refer to such patent or model?

Ans. I made an instrument for the purpose of transmitting two tones simultaneously or singly over a telegraphic circuit which circuit was closed. That (pointing to model marked "Defendant's Exhibit Gray's Two Tone Transmitter") is a duplicate of the instrument which I made.

(The exhibit referred to is put in evidence by the defendant.)

The instrument is also shown in various views in Mr. Gray's English patent of July 29, 1874, being marked "Defendant's Exhibit Johnson Patent, Gray's Magnetic Receiver, W. C. W., Ex'r." (See p. 447.)

Int. 9. You say you made this instrument before May, 1874; state as nearly as you can in what year and month it was?

Ans. It was made or commenced on the fourth of April, 1874.

Int. 10. Did you see this instrument used at or about the time it was made? If so, who was using it and in what manner?

Ans. I used it myself sufficiently to test its workings. I do not know or remember of seeing others use it at that time.

Int. 11. As you used it, upon what were its transmitted tones received?

Ans. Upon a thin plate of metal, represented in figure 3, of the same patent I have referred to, representing the transmitting instrument. The plate of metal forming part of the circuit and being one pole, the body of the operator, being also part of the circuit, and being the other pole of the circuit, by rubbing the thin plate with the palm of the hand, sounds were produced between the plate and the hand. The plate used was a plate of tin or a sheet of German silver; an oyster can probably was also used for the purpose.

Int. 12. Can you furnish us with a reproduction of the plate or sheet of metal, which you say was used as described in the last answer?

Ans. I can't give you the exact shape or form of it, but I can give you a piece that will answer the purpose. There is a piece that will illustrate the plate used.

(The witness refers to a tin plate, which is put in evidence and marked "Defendant's Exhibit Tin Plate Receiver, W. C. W., Ex'r." See p. 447.)

2285

Int. 13. What does the screw which is attached to the side of this exhibit represent?

Ans. A convenient form for connecting it in the circuit, but it was not used for the original test on the original plate, that connection being made by resting the wire upon the plate or the plate upon the wire.

Int. 14. What became of the two-tone transmitting instrument which you made and tried in the manner just described?

Ans. It was sent to Washington as a model for the Patent Office, to accompany Mr. Gray's application for his Animal Tissue patent, so called, being the grant granted July 22, 1875, No. 166,096, marked "Defendant's Exhibit Gray's Animal Tissue Patent, W. C. W., Ex'r."

Int. 15. Did you after making the two-tone transmitter make an instrument for Mr. Gray for transmitting one tone? And if so, please describe the instrument which you so made?

Ans. I did. I have here an instrument, part of which is the original instrument, additions being added for convenience of connections of the line wires and battery. It consisted of a small electro-magnet, with a piece of watch spring attached to one pole and extending across and free from the other; a screw was so placed that it touched the spring when at rest, the battery current passing through the magnet coil to the spring, from there to the screw, touching it back to the battery. The line wire was attached, one end to the screw the other to the spring, forming a continuous circuit from the battery, through the magnet coils, over the line back to the battery. When this spring is in contact with the screw, the battery current is short-circuited through the magnet; when the spring and screw are separated the battery circuit is through the magnet and line; when the battery current is short-circuited a portion of the current is still upon the line, so that the circuit on the line was always closed.

["The instrument referred to by the witness in the above answer and produced by him, is put in evidence for the defendant, and is marked "Gray's First Single Tone Transmitter. W. C. W., Exr." See p. 437.]

Int. 16. What parts of this model are the identical parts, as you said?

Ans. The magnets are the original ones. The watch spring is

new, but the clamp to hold it is the original piece. The heel iron is the original one. The new parts are the base boards and the mountings and the binding screw.

Int. 17. State, as nearly as you can, the time when you made the instrument like Exhibit Gray's First Single Tone Transmitter?

Ans. In the early part of May, 1874.

Int. 18. What means did you use or see used with this First Single Tone Transmitter, for receiving the transmitted tone over the closed circuit you have described?

Ans. I have used it and seen it used with all the various forms of receiver that we have used.

Int. 19. Do you mean that you have used and seen used in this manner the identical instrument which you made in the early part of May, 1874?

Ans. I do.

Int. 20. Please describe each of the receiving instruments you refer to as having been used to receive the single tone from the transmitting instrument just mentioned?

Ans. First. The animal tissue receiver, before mentioned.

Second. Two improved forms of animal tissue receiver.

Third. A paper drum receiver.

Fourth. A magnet receiver, with a hollow tin box placed on or near the poles.

Fifth. Another form of magnet receiver, consisting in a concave metallic diaphragm.

Sixth. Another form of magnet receiver, the magnets enclosed in a box.

Seventh. Another form of magnet receiver, consisting of an iron plate mounted upon a sounding box.

Then there were some receivers used which were modifications of the particular forms I have mentioned.

Int. 21. Referring you now to the two improved forms of animal tissue receivers, will you state what the first one was, and produce it, or a representation of it, and explain the manner in which it was used?

Ans. The first one consisted of a thin plate of German silver mounted upon a violin in place of the strings. This instrument, which I have in my hands, is either the original one or one just like it. When used one of the line wires was connected with the plate, the other held in the hand of the operator; and by his rubbing the

plate with the palm of the hand the tones sent by the transmitter would be produced between the plate and the hand.

The instrument referred to by the witness is put in evidence and marked "Defendant's Exhibit Animal Tissue Violin Receiver. W. C. W., Exr." (See p. 438.)

Int. 22. When and where was Gray's first single-tone transmitter first used with the violin receiver just put in evidence?

Ans. In the early part of May, 1874, at the works of the Western Electric Manufacturing Company in Chicago.

Int. 23. Now, as to the second of the improved forms of animal tissue receiver, will you describe it and its operation, and produce it, or a representation of it?

Ans. In this instrument the plate of metal was mounted upon a revolving disk or drum, so as to attain a continuous forward motion, in connection with the hand, instead of forward and back, as with the violin. I produce an instrument which is a substantial reproduction of the instrument just described.

The instrument produced is put in evidence for the defendant and marked "Defendant's Exhibit Gray's Animal Tissue Revolving Plate Receiver. W. C. W., Exr." (See p. 439.)

Int. 24. In what year and month was this revolving drum receiver first used with the first Gray single tone transmitter, in a closed circuit, as you have described?

Ans. I can't give you the month, but the year was 1875.

Int. 25. Do you mean that that was the first of such a use, or the first that you knew of?

Ans. The first that I knew of.

Int. 26. Was this revolving plate receiver afterwards combined with a diaphragm transmitter for the purpose of transmitting articulate speech through a closed electrical circuit?

Ans. It was.

Int. 27. Is this combination shown in an American patent taken by Mr. Gray?

Ans. It is (except that the form of the transmitter is different) shown in Mr. Gray's patent for speaking telephone No. 210,776, dated December 10, 1878. The diaphragm transmitter shown in the drawing of this patent is the kind known as the water trans-

mitter. The transmitter which was employed in the combination as I saw it was an Edison Carbon Transmitter.

The Gray patent referred to by the witness is put in evidence for the defendant, and marked "Defendant's Exhibit Gray's Revolving Drum Telephone Patent. W. C. W., Exr."

Int. 28. Now, as to the paper drum receiver, will you describe it, and the manner of its use, in connection with the first single tone transmitter in the closed circuit, and produce it, or a representation of it, and state when it was first so used to your knowledge, and where?

Ans. The paper drum receiver consisted of a short cylinder of metal, each end covered with gilt or silver paper, like the heads of a drum, the gilt or silver surface of the paper being in contact with the metal cylinder, a binding post was screwed to the cylinder in contact with it, into which was screwed a metallic handle insulated from it, with a binding post upon it. In using it, one wire of the line was connected to the binding post, fastened to the cylinder, the other wire fastened to the binding post or the handle. Upon holding the handle by the hand and placing the paper drum head in contact with the ear, the sounds sent from the transmitter could be heard. This instrument was first so used in May or June, 1874, at the works of the Electric Manufacturing Company in Chicago. I produce an instrument representing it.

The instrument produced by the witness is marked "Defendant's Exhibit Paper Drum Receiver. W. C. W., Exr." (See p. 440.)

Adjourned to March 22, 1879, at 10.30 A. M.

NEW YORK, March 22, 1879, 10.30 A. M.

Int. 29. Now as to the magnet receiver with a hollow tin box placed on or near the poles of the magnet; will you describe this receiver and the manner of its use in connection with the first single tone transmitter in the closed circuit, and produce it, or a representation of it, and state when it was first so used, to your knowledge, and where?

2289

Ans. The receiving instrument consisted of an electro-magnet mounted upon a wooden base, upon which were placed two binding posts, to which the wires of the coil were connected when placed in the line, the line wires were also connected with the binding posts, forming a continuous circuit from the battery through the transmitting magnet and receiving magnet. A hollow tin box, with holes in the top, was placed upon or held near to the poles of the magnet, when so placed or held, the transmitted tone could be distinctly heard, varying in power the nearer the box was to the poles, without touching them. The first use of it was made in the early part of the month of May, or near the middle, 1874, at the works of the Western Electric Manufacturing Company, in Chicago.

That is a representation of the instrument so used and described.

The witness refers to the model, which is now put in evidence for defendant, and marked "Gray's Resonant Box Magnet Receiver. W. C. W., Exr." (See p. 447.)

Int. 30. What effect was obtained when the box rested upon the poles of the magnet as compared with the effect obtained when the box was near to without touching the magnet?

Ans. The tone was not as loud or as full as when a little separated.

Int. 31. Please describe the manner in which these tests were made, with the box touching the poles, so that we may judge of the value of the practical results obtained?

Ans The transmitting instrument would be placed in one room and the receiving instrument in another, the rooms being from eighty to one hundred feet apart, on the same floor. The sound of the transmitting instrument, disconnected from the line, could not be heard in the room where the receiving instrument was placed. In the room where the receiving instrument was, a great many noises and sounds could be heard from the running of machinery, said room being a little office partitioned off from a large workshop by a low partition, in which perhaps fifty men were employed and making a great deal of noise. When the two instruments were connected in circuit, and the tone being transmitted from the transmitter, and the hollow box resting upon the poles of the magnet, the tone from the receiver could be distinctly heard above the din by a number of persons standing in the room. When the hollow

2290

box was separated slightly from the poles, the tone from it could be heard outside of the small room—in the large one.

Int. 32. Which face of the box was held to or near the magnet—the plain face or the perforated face?

Ans. The plain face.

Int. 33. When the box was held off from the magnet, how was it supported in that position?

Ans. Sometimes by holding the box in one hand and the magnet in the other, and moving them nearer or farther apart, letting the hands rest upon each other to prevent the two from touching; and sometimes by placing upon the heads of the magnet a piece of wood or rubber or other substance, and resting the box upon that, which would keep it separated from the poles the required distance.

Int. 34. Returning for a moment to the revolving drum receiver which you described yesterday, was this ever used by Mr. Gray or under his directions, to your knowledge, with an induction coil. If so, will you state when first, and where it was, and describe the arrangement used and the manner of its use?

Ans. It was used with an induction coil, the primary wires sometimes being attached to the line wires—*i. e.*, the wires extending between the transmitting and receiving stations—and sometimes the secondary wires so attached. The revolving drum, when the line wires were attached to the primary wires of the coil, would be attached to the secondary wires, and when the line wires were attached to the secondary wires of the coil, the revolving drum would be attached to the primary. In this case the current reproducing the tone between the plate of the drum and the hand would be an induced current. The first time I remember of its being so used was in the month of March, 1876, in Philadelphia. It may have been so used before, but I do not now recall it.

Int. 35. Coming now to the fifth form of receiver which you mentioned in your twentieth answer as having been used to receive the single tone over the closed circuit from Gray's First Single Tone Transmitter, namely, a concave metallic diaphragm, will you state when and where such receiver was first made and used to your knowledge, and by whom was it made and by whose directions?

Ans. It was made in the month of July, 1874, at the works of the Western Electric Manufacturing Company, by a man in their employ by the name of Rand, under my direction, in pursuance of instructions from Mr. Gray; and the first time it was used with the

2291

single tone transmitter was at the works of the Western Electric Manufacturing Company during the same month.

Int. 36. Will you describe the apparatus which you have just referred to as the magnet receiver with concave metallic diaphragm, and the manner of its use, and produce it or a *fac-simile* of it?

Ans. It consisted of an electro-magnet, mounted upon a standard which was fastened to a wooden base in combination with an iron pan forming said concave diaphragm, also mounted upon a standard fastened to the wooden base spoken of, in such a manner that the poles of the magnet were in the bowl of the pan, and so arranged, that with an adjusting screw the poles of the magnet could be placed in contact with the bottom of the pan or diaphragm, or separated from it; an additional brace was attached to the magnet, or standard holding the magnet, for supporting the upper rim of the pan, said brace being sometimes used and sometimes removed entirely; the wires from the coil of the magnet were attached to binding posts, also fastened to the base. When in use for receiving tones, the line wires were connected to the binding post, forming a continuous circuit through the transmitting and receiving magnets and battery. There is here present the original instrument made as I have described, and also a *fac-simile* thereof, which I have caused to be made at the request of the counsel for the defendant.

> The fac-simile instrument referred to is put in evidence for the defendant, and marked "Defendant's Exhibit Gray's Concave Metallic Diaphragm Magnet Receiver, W. C. W., Ex'r;" the original instrument referred to by the witness being subject to inspection and comparison with the fac-simile as may be desired by the counsel for complainants at any time during the preparation or hearing of the cause. (See p. 441.)

Int. 37. Was the original instrument just above referred to taken to Europe by Mr. Gray? if so, when?

Ans. It was; in the month of August, 1874.

Int. 38. I wish now to direct your attention particularly to the use by Mr. Gray, or under his direction, prior to his going abroad in August, 1874, of the two receiving instruments represented respectively by "Gray's Resonant Box Magnet Receiver and Gray's Concave Metallic Diaphragm Magnet Receiver." You have spoken of both of these receiving instruments as used prior to August, 1874, in connection with Gray's first single tone transmitter in a

292

closed circuit. If other transmitting instruments were made and used by Mr. Gray, or under his direction, prior to August, 1874, for the electrical transmission of musical tones received upon either of the receiving instruments mentioned in this question, please describe these several transmitting instruments in the order in which they were produced and used, and the nature of the circuit which was maintained between the transmitter and the receiver; and produce such transmitting instruments, if you can, or true reproductions of them.

Ans. In May, 1874, there was constructed, after a variety of experiments, a musical instrument for transmitting melodies. It was constructed substantially upon the plan of the single tone transmitter before alluded to. It was a combination of eight single tone transmitters in one instrument. The connections differed from the single tone transmitter in that when the keys were open or up, the line wire and battery wire were both open. There was a key for each reed, answering to the key of a cabinet organ. When one key was closed, the reed, and magnet connected with it, operated in exactly the same manner that the single tone transmitter did.

In the month of July, 1874, another instrument was made, consisting of two octaves of reeds with semitones. The first instrument spoken of consisted of eight reeds, representing the diatonic scale; the second instrument was like the first, except the addition of more reeds and keys. One other difference: instead of using a magnet for each reed, in the second instrument two reeds, and in one case three reeds, were placed upon the magnets. The connections were the same in both instances. During that same month, July, 1874, two additional single tone transmitters were made, one exactly like the reed and magnet in the first musical transmitter; the other, similar, but with primary and secondary wires wound upon the magnet, forming an induction coil. The single tone transmitters were in closed circuits when used. All the transmitters I have described in this answer were used in connection with the two receivers mentioned in the question before Mr. Gray went abroad in August. Except as I have specified, the single tone transmitters were similar in construction to the first single tone transmitter mentioned by me. I have here the two single tone transmitters made in July, 1874, if it is desired to examine them. I have also the two octave transmitting instrument I have described. The single octave transmitting instrument is in Chicago.

229 3

The two octave instrument produced by the witness is put in evidence for the defendant, and marked "Defendant's Exhibit Gray's Two Octave Transmitter, W. C. W., Ex'r." (See p. 441½.)

Int. 39. For what purpose were the two multiple transmitters (the single octave and the double octave) designed and used? And for what purpose were these single tone transmitters, made in July, 1874, designed and used?

Ans. The two multiple transmitters, single and double octave, were made for the transmission of melodies. The two single tone transmitters were made to show how tones could be used for telegraphic purposes or messages.

Int. 40. And were the two sorts of instruments used for these respective purposes, in connection with the resonant box receiver and the concave metallic diaphragm receiver, before Mr. Gray went abroad in August, 1874?

Ans. They were.

Int. 41. Will you now state on what occasions and to what extent and with what results such uses were made by or under the direction of Mr. Gray before he went abroad in August?

Ans. The first multiple transmitter was not used by me, I believe, in connection with either of these receivers, but was sent to New York and exhibited there in connection with Gray's resonant box magnet receiver, by Mr. Gray, in the month of May or June, or both, 1874. The second multiple transmitter (two octaves) was tested at the works of the Western Electric Manufacturing Company, in connection with both forms of receiver spoken of (the resonant box and concave diaphragm), in the month of July, 1874, and exhibited during the same month in Chicago, between the office of Gen. Stager, superintendent of the Western Union Telegraph Company, Chicago, and the works of the Western Electric Manufacturing Company, of Chicago. The distance of the two instruments apart was about three-quarters of a mile, the receiver being at the office of Gen. Stager and the transmitting instrument at the other end. The two single tone transmitters were experimented with in connection with both forms of receivers at the works of the Western Electric Manufacturing Company, but not exhibited, to my knowledge, except as people came in while being experimented with and seeing them.

Int. 42. Referring particularly to the exhibition of the double octave multiple transmitter with the resonant box receiver and con-

2294

cave diaphragm receiver in July, 1874, between Gen. Stager's office and the works of the Western Electric Manufacturing Company, state, as nearly as may be, how many persons witnessed this exhibition, naming such of them as you can, first stating whether the exhibition was public or private.

Ans. I do not know whether it was a public or a private exhibition, nor what persons were present, and I don't know but I ought to add which of the receiving instruments, if either, was used, I being at the transmitting end, three-quarters of a mile away.

Int. 43. As regards the demonstration which took place previously, at the works of the Western Electric Manufacturing Company, did you assist in that, and if so, at which station?

Ans. I did assist in that, principally at the transmitting station, occasionally changing to the receiving station.

Int. 44. Was this demonstration conducted between the same two rooms you mentioned before when speaking of the first single tone transmitter, or between other points in the shop?

Ans. In both places,—in the rooms spoken of previously, and in the same room, with instruments near together.

Int. 45. Can you name any persons who witnessed these demonstrations at the shop?

Ans. I can name persons that I feel very positive were there; Mr. E. M. Barton, secretary of the Western Electric Manufacturing Company, Mr. N. G. Kellogg, Charles Lewis, foreman of the shop. Those are all the names I would specify, but there were fifty to one hundred men employed there who could have seen it, and probably many of them did.

Int. 46. Please state the result of the demonstration had at that time with the apparatus you have referred to?

Ans. The result was satisfactory; so much so that the apparatus was shipped to London, England, to exhibit to certain scientific men there.

Int. 47. In this demonstration of the Western Electric Manufacturing Company's shop, in what, if any, different ways were the resonant box and the concave metallic diaphragm used as regards contact with, or proximity to the magnet; and with what comparative result as to the distinctness of hearing or reproduction of the tones, whether as regards a comparison of the two forms of receiver with one another, or as regards the comparison of different positions relatively to the magnet to which either was adjusted?

Ans. The instruments were used sometimes with the magnet in

2295

contact with resonant box and concave diaphragm, and also at various degrees of distance apart. Distinctness of hearing or reproduction of the tones was better when the box and concave diaphragm were separated from the magnet. I do not know that we tried to determine which form of receiver was the best for reproduction of the tone or hearing. The concave diaphragm magnet receiver was the most convenient form for using, as it could be adjusted and remain adjusted so that it could be used a second time without having to stop to adjust.

Int. 48. How far from the resonant box or concave diaphragm could you stand and hear distinctly the tone transmitted to it and received by it in the demonstration you are describing?

Ans. I don't know how far we could have heard the sounds; we did stand about the receiving instrument perhaps about three to ten feet from it and heard it distinctly.

Int. 49. Was there any difference that you noted or remember between the resonant box and the concave diaphragm as to the distinctness of hearing under similar relations of the two things to the magnet—similar proximity?

Ans. I do not remember now a comparison of the two instruments in that respect. I mean the result of any comparison that may have been made, if any was made, which I do not remember.

Int. 50. You have said that Mr. Gray went abroad in August, 1874. Did you go with him?

Ans. I did.

Int. 51. What instruments did you and he take with you?

Ans. The two-octave multiple transmitter, the two single tone transmitters made in July, the violin animal tissue receiver, the concave diaphragm magnet receiver. These, I think, were all the instruments that we took.

Int. 52. State what, if any, exhibitions of these instruments and their operation in circuit for receiving and transmitting musical tones, were made by you and Mr. Gray, or by him in your presence, while you and he were in Europe?

A. The instruments were unpacked in the office of Warden, Muirhead & Clark, Regent street, London, in September, 1874. The multiple transmitter, with one or more receivers, was connected in circuit and exhibited to members of the firm, melodies being transmitted from one room and received in another. Afterwards, during the same month, the apparatus was removed to the office of Latimer Clark, No. 6 Victoria Chambers, London, and exhibited there to

2296

him. Afterwards parts of it were taken to the laboratary of Prof. Tyndall, at the Royal Institution, London, and exhibited to him about the 1st of October, 1874. It was afterwards taken back to the office of Latimer Clark, and exhibited to such of his friends as he invited in.

Adjourned to March 24, 1879, at 10.30 A. M.

NEW YORK, March 24, 1879, 10.30 A. M.

Int. 53. What was the business of Warden, Muirhead & Clark, and what was their standing in that business in 1874 in England?

Ans. They were manufacturers and dealers of nearly all forms of telegraphic supplies, and I believe one of the largest firms in the business.

Int. 54. State as nearly as may be how frequently and with what degree of publicity the exhibitions of those instruments were made at the office of Warden, Muirhead & Clark, at Regent street, and at the office of Mr. Clark, in Victoria Chambers?

Ans. At the office of Warden, Muirhead & Clark, I think the exhibition was only witnessed by members of the firm and perhaps one or two persons in their employ. I do not remember how many times, but the apparatus was in condition for exhibition several days. At the office of Mr. Clark, in Victoria Chambers, the apparatus remained in working order two or three weeks—perhaps more. I don't remember exactly, and was exhibited to as many of his friends and as often as he desired.

Int. 55. In your last answer you used the expressions "in condition for exhibition" and in "working order." What doy ou mean by these expressions?

Ans. The instruments were connected with battery and with line and with each other, and could be used at a moment's notice.

Int. 56. You say, "The multiple transmitter, with one or more receivers, was connected in circuit," &c. What receivers do you there refer to?

Ans. I do not mean by that that there were two receivers in the line at once. I should have said, perhaps one or other of the receivers was so connected.

Int. 57. Were all the receivers which you took out with you

2297

exhibited at one time or other in circuit with the multiple transmitter?

Ans. I cannot swear that they were, as I was at the transmitting end of the line, and could not tell positively which receiver was being used.

Int. 58. You say that parts of the apparatus were taken to the laboratory of Prof. Tyndall and exhibited to him. What parts were these?

Ans. The multiple transmitter, the violin animal tissue receiver, and, I think, the concave diaphragm magnet receiver and the paper drum receiver which we had made in England.

Int. 59. When did you and Mr. Gray return to this country, and what did you do with the apparatus before leaving England?

Ans. We left England for home the 8th of October, I believe, 1874. Before leaving the apparatus was taken to the office of Warden, Muirhead & Clark, and arrangements made with them for shipping it to this country.

Int. 60. State, if you know, when the apparatus next came into the possession of Mr. Gray, and state all you know of your own knowledge in regard to its detention from his possession in the meantime.

Ans. I did not see the apparatus after leaving England until some time in the fall of 1875. I know very little of the causes of detention. I understood it was through some informality with regard to the custom house.

Int. 61. Did you finally receive them in the fall of 1875 at Chicago?

Ans. I did.

Int. 62. All which were sent out to England?

Ans. Yes, sir.

Int. 63. After the multiple transmitter and concave diaphragm receiver so came into your possession again at Chicago, what was their history with reference to the place where and manner in which they were preserved, and with reference to any use made of them at Chicago or elsewhere for any purpose?

Ans. They were kept at the works of the Western Electric Manufacturing Company with other apparatus which we have stored there. The multiple transmitter was used as an exhibit in a suit of interference between Mr. Gray and Edison, and sent to Washington as such exhibit, in May or June, 1877. The concave diaphragm receiver remained in the store-room in Chicago until sent to New

2298

York for uses in this case. The multiple transmitter was finally returned to Chicago from Washington, and also brought to New York for uses in this case.

Int. 64. Was there more than one resonant box magnet receiver like the exhibit of that name made in Chicago for Mr. Gray, and before he went abroad in 1874?

Ans. There were two of them made.

Int. 65. State what was the history of each?

Ans. One was sent to New York and exhibited there in connection with the first eight-tone transmitter, in May or June, 1874, and left there, I believe. The other was sent to Washington as a model in a patent case.

Int. 66. Do you mean as a model accompanying an application for a patent?

Ans. I do.

Int. 67. What patent?

Ans. The magnet receiver patent, I believe it is called No. 166,095, July 27th, 1875.

Int. 68. You described, last Saturday, certain tests which were made of the resonant box receiver with the first single tone transmitter in closed circuit, the operations being performed on premises of the Western Electric Manufacturing Company, the transmitting instrument and the receiving instrument being in separate rooms from eighty to one hundred feet apart. I believe you have not said, and I will ask you now to say, whom, if any one you can name, besides Mr. Gray and yourself, who witnessed this exhibition?

Ans. I cannot definitely state who did witness it, but think E. M. Barton and Mr. M. G. Kellog were present, and probably others.

Int. 69. Was the exhibition conducted openly for the observation of any who desired to see it, or was it privately?

Ans. It was not private in any sense.

Int. 70. In speaking of this same exhibition or demonstration, you describe the manner in which the resonant box was supported when it was held near to, but not touching the magnet poles, and this you said was "sometimes by placing upon the heads of the magnet a piece of wood or rubber, or other substance, and resting the box upon that." This description is, perhaps, not entirely clear. Will you state what you mean by the heads of the magnet and how the pieces of wood, &c., were made to properly support the box?

Ans. By heads of the magnet, I mean the hard rubber disks that

2299

form the end of the spool through which the magnet poles project. When the resonant box was supported by pieces of wood or other substances, they were placed upon the rubber end of the spool near the outer edge and on opposite sides, the box resting upon them.

Int. 71. Have you here, and will you produce a diagram model, representing Gray's first single tone transmitter, and its battery connections, and the magnet receiver, and explain its operation of transmitting the tone through a closed circuit?

Ans. Yes; I have. (The diagram model produced is put in evidence for the defendant, and marked "Gray's Closed Circuit Single Tone Transmission Apparatus, W. C. W., Examiner.") The single tone transmitter is represented and marked with letter A, the magnet receiver with the letter B, the battery by C, a key in short circuit by D, and in this model, instead of two wires representing line and return, the return is represented by ground connections marked E and E^1, and the line by F^1. When the key D is opened, the battery current is through transmitting magnet A and line F, and receiving magnet B to the ground plates back to battery. When the key D is closed the current passes through the transmitting magnet A to a point represented by G, where it divides, a portion going over the line F and receiving magnet B and ground plates back to battery, the rest passing through the core of the transmitting magnet A to the spring or reed, and when in contact with the screw (shown in the model in contact with it), through it to the key back to battery. When the spring spoken of is in contact with the screw, most of the battery current is through the short circuit, making the transmitting magnet very strong, thereby attracting the spring toward the magnet and away from the screw, which sends all of the current over the line, which has the effect of weakening the power of the transmitting magnet, and allowing the spring or reed to fall back against the screw, which operation alternates or changes the power of the current upon the line.

Int. 72. Did you after your return from Europe, make an apparatus, and for what purpose, such as is shown in Gray's Tuned Bar Receiver Patent No. 166,094, and if so, how soon after your return?

Ans. I made or had made such an instrument as is described in Gray's Tuned Bar Receiver Patent, in the months of November or December, 1874, for the purpose of analyzing or responding to a

2300

particular tone or vibration sent from the transmitting station either alone or with others.

Int. 73. At this time did you have such an instrument at both the receiving and transmitting stations of the line?

Ans. The instruments were alike in form at the two ends, but differently connected, and were not interchangeable.

Int. 74. During this winter of 1874 and 1875, did you have occasion for a multiple transmitter similar to that heretofore mentioned, if so, what did you do, the multiple transmitter sent from England being at that time detained in the Custom House as you have said?

Ans. I had another one constructed with the same number of tones (two octaves with semi-tones).

Int. 75. When was this done? And if an apparatus was at the time constructed which this multiple transmitter worked in connection with, will you explain the whole apparatus and its arrangements and purpose and operation, producing such representations of it as will be convenient for the purpose of explanation?

Ans. This multiple transmitting instrument was made or completed in December, 1874, and about the same time, during the same month, a new form of magnet receiver was made, which had, in the place of the spring or reed, a plate of iron about three inches in diameter, octagon in shape; said magnet and plate combined mounted upon a hollow wooden box for resonance. This (producing an instrument) is the identical box and magnet spoken of; the thin octagonal plate of iron not now being mounted with it, but replaced by a different piece of iron, oblong in shape. The original octagonal plate I also have, and produce it. There were five of such plates and magnet receivers made at the same time, four of which magnets and plates were mounted upon resonant boxes, the other mounted upon three legs and used in different ways.

The instrument produced by the witness is put in evidence for the defendant, and marked "Gray's Wooden Sounding box Magnet Receiver, W. C. W. Ex'r." and the octagonal plate produced by the witness is put in evidence for the defendant and marked "Gray's Octagonal Plate, W. C. W. Ex'r." (See p. 443.)

In regard to this combination of magnet and octagonal iron plate, I would add that when a strong battery current was used, the

iron plate would sometimes be attracted and held firmly to the magnet. To prevent it we sometimes used a little brace of wood placed between the two coils of the magnet, one end touching the octagonal plate; the other touching the cross bar or heel iron of the magnet, and sometimes a piece of rubber or other substance would be placed between the plate and rubber head of the magnet at that side of the plate which was free from the magnet.

Int. 76. What was the object of providing the means of greater resonance which you have described as appertaining to this apparatus, and what use was made of the apparatus organized as you have described?

Ans. The object was to have the tone or tones reproduced loud enough to be heard in a large hall; and the use made of it at that time was an exhibition to the public in a church in Highland Park, Illinois, during the last week of December, 1874.

Int. 77. Did you afterwards make or assist in making for Mr. Gray a modification of one of the magnet receivers you have described, with a view to the telegraphic transmission of messages over long lines? If so, please say when it was, and describe it, and produce it, or a representation of it?

Ans. I made or had made, such modification as spoken of in the question for the purpose of a long line test, and have part of the original instrument here, which consists of a tin cup or dipper with a cover of wood upon which is mounted an electro-magnet in such a manner that when the cover is in place upon the dipper or box, the magnets are inclosed in the box, the poles of which magnet are nearly touching the bottom of the box. Upon the wooden cover of the box are mounted two binding posts, with which the wires from the magnet coil are connected. In the bottom of the box some holes are drilled for the purpose of letting out the sound. The binding post upon the side of the dipper or box was put on for a handle, into which sometimes was screwed a wooden handle.

Int. 78. Will you produce the instrument which you described in your last answer as illustrating the apparatus inquired about, state what parts of it are the original parts, and what parts are a reproduction of the original parts?

Ans. I do produce it. (The instrument produced is put in evidence for the defendant, and marked "Diaphragm Box Magnet Receiver, W. C. W., Ex'r.") The tin box or dipper, as it stands, is the original part. The cover, magnet and binding posts are reproductions of the original.

Int. 79. Explain how you used this instrument?

Ans. This instrument was used in connection with a transmitting instrument upon a telegraph line between Chicago and Milwaukee, near the middle of February, 1875; and the manner of its use is represented by the diagram model marked "Grays' Closed Circuit Single Tone Transmission Apparatus."

Int. 80. When the apparatus was in operation, how was the receiver held for the purpose of receiving the transmitted tone?

Ans. I was not at the receiving end and did not see it used. It could have been held in the hand and applied to the ear, or it could have rested upon a table.

Int. 81. In the latter case, which side should be uppermost, and in the former case, which side should be applied to the ear?

Ans. When resting upon a table, it could be placed upon its side or rested upon the cover and binding posts, the perforated tin diaphragm being outermost. When applied to the ear, the perforated tin diaphragm was towards the ear.

Int. 82. Have you since that time used it yourself in either, and which of the two ways you have mentioned?

Ans. I have in both ways.

Int. 83. You have said that this instrument was used in connection with a transmitting instrument upon a telegraph line between Chicago and Milwaukee, near the middle of February, 1875, under such arrangement as I understand you, for transmitting and receiving as shown in the diagram model marked "Closed Circuit Single Tone Transmission Apparatus." At which station were you, and who was at the other station?

Ans. I was at the Chicago end of the line with the transmitting instrument, and Mr. Gray was in Milwaukee with the receiving apparatus.

Int. 84. To what extent was this telegraphing operation with this apparatus carried on; and whether publicly or privately, and with what result?

Ans. It was used the greater part of one afternoon; say from three o'clock, or half-past two to six o'clock. It was not a private exhibition, as the transmitting instrument was in a room occupied by fifty or more telegraph operators, all of them probably having a look at it. I can't answer as to the other end, but think it was as public as the transmitting end. The results, I think, were satisfactory.

Int. 85. When you were describing Gray's Wooden Sounding

2303

Box Magnet Receiver, you said that it was provided with an octagon shaped plate under the magnet poles, in place of the oblong metal bar which is now in the exhibit. When was an instrument first used by Mr. Gray with the oblong bar as now appears in the exhibit?

Ans. I do not remember the date of its first use; it was in the spring or summer of 1875.

Int. 86. In the case of the multiple transmitters which were made before you went abroad and directly after your return, how was the intensity of volume of the tones received affected by sounding two or more tones simultaneously upon the transmitter, after the manner of the musical chord, as compared with sounding one tone by itself?

Ans. The volume of the tone or tones was very much less when two tones were being transmitted than when only one was sent.

Int. 87. To what was this difference due, and what change, if any, was afterwards made in the transmitting apparatus or its connections in order that each tone of a chord should have a volume equal to that of one tone sounded separately?

Ans. It was due to the fact that when two tones were being transmitted, the battery current was divided, part being vibrated by one reed, the rest by the other. When one tone alone was being sent, it vibrated the entire battery current. The change made to get the same volume for each tone was a change in the manner of connecting the battery so as to give to each vibrating reed a proper proportion of the battery. In this method of connecting up, no one reed can vibrate the whole battery current.

Int. 88. Is the arrangement of the battery you have referred to, for the purpose of producing a number of tones simultaneously, shown in any of Mr. Gray's patents, if so, which?

Ans. It is shown in two of them. In the patent, No. 175,971, "Sounding Box Receiver Patent," it is shown for transmitting and receiving two tones; and in the patent No. 186,340, "Closed Circuit Patent," it is shown for transmitting and receiving six tones.

Int. 89. When first did Mr. Gray have and use an apparatus in which a multiple transmitter capable of sending a number of tones simultaneously, each of the volume of one tone sounded separately, and with such multiple transmitter, a bar of metal opposite the poles of the magnets, as shown in the Sounding Box Exhibit, and with the circuit constantly closed and the magnet constantly charged?

Ans. The first I remember of such use was in September, 1875. He had the apparatus and could have used it then, and perhaps did, a month or more earlier.

Int. 90. What, if anything, did you have to do with the making of this apparatus embodying the combination you have described?

Ans. I superintended the construction of it. It was made at the works of the Western Electric Manufacturing Company, in Chicago.

Int. 91. In which one, if either, of Mr. Gray's patents is the apparatus you have mentioned represented?

Ans. In Mr. Gray's patent No. 205,378, marked "Gray's Common Receiver Patent."

Int. 92. In this apparatus, was the composite tone which was transmitted by sounding a chord, for instance upon the transmitter, delivered to the ear at the receiving end in corresponding composite form?

Ans. It was.

Int. 93. Why was not this result hindered by the sound of the fundamental tone of the oblong bar in the receiver?

Ans. Because of the fundamental tone of the receiver was probably very much lower in pitch, or slower in rate of vibration, than the tones transmitted, for one thing, and not being one of the tones transmitted.

Int. 94. Was an experimental use made of this apparatus at or about the time of its completion, and where, and to what extent, and with what results?

Ans. In my answer to the eighty-ninth question I speak of the first use I remembered of this combination. In September, 1875, in New York, in the Western Union building, the apparatus was set up and connected in the manner spoken of, and exhibited to a number of people.

Int. 95. On this occasion, were a number of telegraphic messages sent simultaneously through the medium of simultaneous musical tones; and if so, how many, and how distinguished or resolved at the receiving end?

Ans. There were four messages transmitted simultaneously, and received by four persons, who wrote them down as they received them, each person selecting a tone and copying the message sent by use of that particular tone.

Int. 96. When and where did you first see such an instrument

as is now commonlly called the Lover's Telegraph, and will you describe it?

Ans. I first saw this instrument in December, 1875, in Milwaukee, Wisconsin; it consisted of a short tube, or rather two short tubes, with a diaphragm stretched across one end of each, the diaphragm being a thin piece of skin or parchment, and having a strong thread fastened to the centre of each diaphragm, the thread being about twenty or thirty feet long. When used, the thread between the two diaphragms was stretched tightly, and upon a person speaking into one tube, the person holding the other by listening at the tube could hear and understand the spoken words, even if spoken in a whisper.

Int. 97. State, if you know, when the Patent Office model of the apparatus shown in Mr. Gray's "Printer Patent," No. 179,549, was made.

Ans. In the spring or summer of 1875.

Int. 98. State, if you know, when the Patent Office model of the apparatus shown in Mr. Gray's "Double-bar Magnet Patent" No. 198,379, was made?

Ans. It was made in March, 1876.

Adjourned to March 25th, 1879, 10.30 A. M.

NEW YORK, March 25, 1879, 10.30 A. M.

Int. 99. Have you at any time, in Chicago, undertaken to use experimentally any of the receiving instruments mentioned in this deposition for the purpose of transmitting or receiving, or both transmitting and receiving articulate speech; if so, please state the time when it was done, the instruments which were used, the conditions as to distance, etc., under which they were used, and the results obtained?

Ans. In October or November, 1878, in Chicago, at the works of the Western Electric Manufacturing Company, I connected up several of the receivers mentioned; namely, the resonant box magnet receiver represented by Exhibit marked "Gray's Resonant Box Magnet Receiver;" the concave metallic diaphragm magnet receiver, represented by Exhibit marked "Gray's Concave Metallic Diaphragm Magnet Receiver," and the diaphragm box magnet re-

ceiver, marked "Exhibit Diaphragm Box Magnet Receiver," in combination with an Edison Transmitter; there was but one of the receivers in use at the same time. Upon speaking to the Edison transmitter the sound of the voice, or the spoken words was reproduced upon either of the above mentioned receivers. Substituting the diaphragm box magnet receiver for the Edison transmitter, and having the concave metallic diaphragm magnet receiver connected at the other end of the line, upon speaking to the diaphragm of either one, words were heard by listening at the diaphragm of the other distinctly. The resonant box magnet receiver was also used as transmitter or receiver in connection with the other forms of receivers spoken of, and words spoken to it, or the diaphragm of it, were heard from the diaphragm of the concave metallic diaphragm receiver or the diaphragm box magnet receiver. The distance between transmitting and receiving instruments was from fifty to one hundred feet, on different floors, there being no possibility of hearing what was said in one through the air in the other.

Int. 100. Who talked when you listened through these instruments and *vice versa?*

Ans. Mr. N. G. Kellogg and Mr. E. M. Barton.

Int. 101. Have you since the beginning of the present year assisted in certain experiments, conducted under the direction of Mr. Edward E. Renwick, relating to the telephonic transmission of articulate speech by means of the receiving apparatus mentioned in your deposition; if so, when and where were these experiments conducted?

Ans. I assisted Mr. Renwick in some experiments during the month of February, 1879, in New York City, at the shop of the Western Union Telegraph Company, superintended by Mr. G. M. Phelps.

Int. 102. In the course of these experiments did you use a receiver such as Exhibit Diaphragm Box Magnet Receiver; if so, state with what transmitter, with what battery power, and with what result?

Ans. Yes; the transmitter was an Edison Carbon Transmitter, the battery power sometimes being one cell (Callaud) and sometimes three and sometimes six. Words spoken to the carbon transmitter were heard and understood by the person listening at the receiver.

Int. 103. Who was at the transmitting end?

Ans. I was for one, Mr. Glass, foreman of the shop, and Mr.

Renwick, also. I was sometimes at the transmitting end and sometimes at the receiving end.

Int. 104. In the course of the same experiments did you try with an Edison Transmitter a resonant box, square instead of round in form, but otherwise like that attached to the Exhibit Gray's Resonant Box Magnet Receiver, and, if so, with what results, stating also whether the same persons were at the transmitting and at the receiving end, as in the case mentioned in your last answer?

Ans. Yes. A square tin box was sometimes used on the magnet in place of the round one, with equally good results, and, I think, used by the same parties.

Int. 105. In each case, as I understand you, whether with the square box or with the round box, the box resting on the poles of the receiving magnet?

Ans. They did, while I was listening.

Int. 106. I understand you to say that, as between the square box and the round box, both used as just described, there was no difference either in the distinctness or in the loudness of the articulate sound proceeding from the receiving end, as regards what you yourself listened to; am I right?

Ans. You are.

Int. 107. Comparing these two forms of resonant box receiver with the diaphragm box magnet receiver, which gave a better result, if either, and in what degree and in what respect better?

Ans. The diaphragm box magnet receiver gave the best results, being louder.

Int. 108. In the course of the same experiments, and with the same persons at the receiving and transmitting end, respectively, as before, and with an Edison transmitter, did you try Gray's concave metallic diaphragm magnet receiver, and with what results?

Ans. We did, with results, as near as I can remember, the same as with the diaphragm box magnet receiver. In my listening I was not endeavoring to compare the instruments but to ascertain if I could understand spoken words.

CROSS-EXAMINATION BY CHAUNCEY SMITH, ESQ., of counsel for complainant:

Cross-Int. 109. You have spoken of various trials which you made with certain instruments which have been referred to as exhibits in the case or with the originals, which the exhibits are de-

signed to represent. Have you given a full account of all the trials which you witnessed of the original instruments or of the instruments representing the originals which have been produced in evidence?

Ans. No, sir.

Cross-Int. 110. Will you state what trials you witnessed of the various original instruments beyond those which you testified to in your direct examination, taking them in the order in which the exhibits were introduced in evidence?

Ans. Of the first two tone transmitting instrument, marked "Gray's Two-Tone Transmitter," referred to in my eighth answer, I witnessed no use of it other than that mentioned in the tenth answer. The next instrument referred to was a thin plate of metal mentioned in the eleventh answer. I do not know that the original plate has been used since the time mentioned in the eleventh answer. We had about the premises plates of various kinds of metal, and we used what happened to be convenient for the purpose; there were several oyster cans lying about, and my impression is that one was also used.

The next instrument in order is mentioned in the fifteenth question. I believe I have not spoken of any particular trial made with this instrument, but stated that I had used it with all the various forms of receiver.

Next, the improved form of animal tissue violin receiver, described in the twenty-first answer. This instrument has been used in a great variety of experiments. The original was sent to New York in May, 1874, and remained there, I think, about two years. While it was away others were made like it and used in place of it, and when it came back I could not tell which was the original.

The next instrument put in evidence is mentioned in the twenty-third answer and marked "Gray's Animal Tissue Revolving Plate Receiver." The original instrument has been used a great many times in experiment at the works of the Western Electric Manufacturing Company, and exhibited publicly. I cannot name all the trials I witnessed.

The next instrument is described in the answer to the twenty-eighth question, and is marked "Paper Drum Receiver." The original was used but a short time, and was soon destroyed.

The next instrument is described in the answer to the twenty-ninth question, and is marked "Resonant Box Magnet Receiver," the original; there were two originals, one of which I had never

7369

seen used, aside from the use spoken of in this twenty-ninth answer; the other was sent to New York in May, 1874, and I am not sure that I have ever seen it since.

The next instrument is described in the thirty-sixth answer, and marked "Concave Metallic Disphragm Magnet Receiver." I think I have mentioned all of the trials I have witnessed with this instrument. If there are others, they do not now occur to me.

The next instrument put in evidence is referred to in the thirty-eighth answer, and is marked "Two Octave Transmitter." I think I have referred in my evidence to all the trials witnessed by me with the original instrument.

The next instrument put in evidence is referred to in the seventy-fifth answer and is marked "Wooden Sounding Box Magnet Receiver." I do not recall any trial I witnessed of the original instrument other than I have mentioned in my evidence, unless it may have been some tests when it was first completed.

The next instrument put in evidence is referred to in the seventy-eighth answer and marked "Diaphragm Box Magnet Receiver." I do not recall any trial with the original instrument other than I have mentioned.

Cross-Int. 111. In your answer to the eighth interrogatory, in reference to Gray's original two-tone transmitter, a duplicate of which you have produced in evidence, you say. "I made an instrument for the purpose of transmitting two tones simultaneously or singly over a telegraphic circuit, which circuit was closed." Do you mean to be understood by this that that part of the transmitting instrument which produced the tones to be transmitted was included in a circuit which was constantly closed?

Ans. I do not.

Cross-Int. 112. Was there between that portion of the transmitting instrument to which I last referred and the receiving instrument an electric circuit connecting them, which was constantly closed?

Ans. There was not.

Cross-Int. 113. What, then, did you refer to in the answer, which I have quoted, as a telegraphic circuit, which circuit was closed?

Ans. To the secondary wires of the said transmitting instrument in connection with the line and receiving instrument.

Cross-Int. 114. Was there a constant current flowing in this closed circuit?

2310

Ans. There was not.

Cross-Int. 115. How did the breaks in the current in this circuit correspond with the breaks in the current of the circuit connected with that portion of the transmitting instrument which produced the sound caused by the breaking of that circuit?

Ans. The impulses upon the secondary circuit were of the same rate, exactly as those produced in the primary circuit.

Cross-Int. 116. Was this instrument, which you have produced in evidence as a duplicate of the original referred to in your eighth answer, made by yourself or under your direction?

Ans. Under my direction.

Cross-Int. 117. When was it made and for what purpose?

Ans. It was made in October or November, 1878, possibly a little earlier for use in this case.

Cross-Int. 118. How many instruments like this, or like the original have been made in all, to your knowledge?

Ans. Three, including the original.

Cross-Int. 119. You speak of this as a duplicate of the original. Is it a duplicate in all respects of the original, including the dimensions of the cores of the magnets, the size and length of the wire, and the manner in which they are wound?

Ans. Probably the separate parts of this instrument are not exactly duplicates of corresponding parts of the original in point of dimension. The wire with which it is wound may not be exactly of the same length as the wires of the original. It was made from a Patent Office drawing of the original, and intended to be as near like the original as it could be made without having possession of the original, the original being in the Patent Office.

Cross-Int. 120. Can you give the particulars mentioned in the last question as to the original instrument?

Ans. I cannot give you the dimensions nor the length of the wires; the primary wire was wound first upon the coil, and the secondary wire upon that.

Cross-Int. 121. Can you give the same particulars in respect to the instrument which has been put in evidence?

Ans. Just the same.

Cross-Int. 122. State whether or not, in the induction coil in the instrument produced in evidence, the wires of the two circuits are of the same size, and what their lengths are relatively to each other?

Ans. I cannot state positively whether there is a difference in size

7311

of the two wires, as I did not see the wire wound upon it, and the size cannot be ascertained from the outside; I suppose the primary wire to be larger than the secondary, as that is the customary way of winding induction coils; in regard to the length of the wire, we pay no attention to the length, instead of which we speak of it as of being certain resistance; in this case there is, probably, one or two ohms of resistance in the primary wire, and perhaps fifty ohms in the secondary; I do not remember the exact proportions.

Cross-Int. 123. You spoke of the original instrument being used in connection with the plate on which the tones of the transmitting instrument was reproduced; was the reproduction of these tones the ultimate object of the use of the apparatus, or was there some other and further useful results to be obtained by it, as you understood it?

Ans. I did not know whether there was any other object in view or not.

Cross-Int. 124. Did you ever see it used for transmitting words or messages from a person at the transmitting instrument to a person at the receiving instrument?

Ans. I did not.

Cross-Int. 125. You have produced an exhibit marked "Defendant's Exhibit Gray's Resonant Box Magnet Receiver," as representing an original instrument, if I understand you, made in 1874; will you state whether or not the magnets and box are identically like the original instrument in respect to the dimensions of the parts, including the size and length of the wires?

Ans. I presume they are not identically like the original, as I understand the word.

Cross-Int. 126. Do you remember what the dimensions of the original were?

Ans. Not exactly.

Cross-Int. 127. Will you state as near as you can what the dimensions were, including the size and resistance of the wire?

Ans I think the iron cores were a little less than half an inch in diameter, and about three inches long; the wire upon them measured about forty ohms in resistance.

Cross-Int. 128. Do you remember whether that original electromagnet was constructed especially for use and connection with the single tone transmitter with which it was used, or was one manufactured by the company for sale or for use for other purposes?

A. We found a magnet such as was used by the company for instruments of their construction, and adapted it to this purpose.

Cross-Int. 129. What adaptation did it require?

A. Mounting it upon a wooden base with binding posts, as represented by the exhibit.

Cross-Int. 130. Do you remember also whether you found the box which was used in connection with it, or made one especially for it?

Ans. I had two boxes made especially for the purpose.

Cross-Int. 131. And were these boxes of the same dimensions as that which you have produced as a part of the exhibit?

Ans. They were not, exactly.

Cross-Int. 132. In speaking of the use of the original instrument in connection with the single tone transmitter, I understand you to say that you reproduced the tones of the transmitting instrument; did you understand that a reproduction of such tones was the ultimate object of the apparatus, or that it was designed to be used for attaining some other and further object?

Ans. I was not aware of any other object at that time.

Cross-Int. 133. Was that true also of the use of the instrument in connection with the original concave metallic diaphragm receiver which you have produced?

Ans. At the time it was produced it was.

Cross-Int. 134. When did you first become aware, if ever, of any further use which was to be made of these instruments?

Ans. In the winter of 1874 and 1875, in experiments with similar instruments, we were led to believe that they could be used as receivers for the human voice.

Cross-Int. 135. By the use of the single tone transmitter in connection with which they were used?

Ans. No, sir.

Cross-Int. 136. Was any effort made to use them as receivers for the human voice?

Ans. No, sir.

Cross-Int. 137. Did you know of Mr. Gray's contemplating the use of these receivers in connection with the single tone transmitter which you have described, or in connection with an instrument like the Exhibit Gray's Two Tone Transmitter, for transmitting messages or intelligence from a person at the transmitting instrument to a person at the receiving instrument?

Ans. I understood that that was the object of the invention—to transmit messages from one person to another.

Cross-Int. 138. In what way?

Ans. By the use of the tone or tones transmitted and received telegraphically, by breaking the tone or tones into short and long sounds, corresponding to the dot and dash of the Morse alphabet.

Cross-Int. 139. Did you ever, in the use of the single tone transmitter in connection with the electro-magnet, of which a representation is given in Exhibit Gray's Resonant Box Magnet Receiver, use the electro-magnet alone for reproducing tones?

Ans. I did.

Cross-Int. 140. And with what result?

Ans. I heard the tone plainly.

Cross-Int. 141. Did you not know before you went to England that Mr. Gray contemplated the use of transmitters like Exhibit Gray's Two-Tone Transmitter, in connection with an electro-magnet alone, for transmitting two telegraph messages simultaneously?

Ans. No, sir.

Cross-Int. 142. When, if ever, did you first learn that he contemplated the use of the apparatus mentioned in that way?

Ans. I don't know that I ever learned it.

Cross-Int. 143. Did you ever know of his contemplating the transmission of two messages simultaneously by any means—and if so, by what means?

Ans. I did, by the means of an electric current thrown into vibration by reeds differing in pitch, and receiving the results of such vibrations of currents upon instruments capable of responding to such vibration, receiving the two or more tones upon a single receiving instrument or upon separate instruments designed for responding each to a particular tone.

Cross-Int. 144. When did you first know that?

Ans. I first knew of his contemplating accomplishing this result in April or May, 1874.

Cross-Int. 145. What instruments did you first know of by which this result was to be obtained, or sought to be obtained?

Ans. The two-tone transmitter, represented by Exhibit so marked, and the resonant box magnet receiver, represented by exhibit so marked.

Adjourned to March 26, 1879, at 10.30.

2514

NEW YORK, March 26, 1879, 10.30 A. M.

Cross-Int. 146. What batteries did you use in the various trials or experiments which you have mentioned in connection with the several receivers?

Ans. I think we used three different forms, Callaud's or gravity battery, Grove battery and carbon battery; sometimes using but one cell, and at other times a number of them. Just how many I do not remember.

Cross-Int. 147. Will you give me the data as to the electro-magnet used in connection with the concave metallic diaphragm receiver, and also as to that used in connection with the diaphragm box-magnet receiver?

Ans. I have here the original instrument, concave metallic diaphragm receiver, which can be examined as to its resemblance to the exhibit. The cores of the magnet are about half an inch in diameter, and about four inches long, perhaps a little more. The resistance of the wire upon the magnet I do not remember. I think the resistance is in the neighborhood of one hundred ohms. It may be more or less. The magnets of the diaphragm box receiver had cores of about an inch and one-half in length, and a quarter of an inch in diamater, and I think the wire upon them had from one to two hundred ohms resistance.

Cross-Int. 148. Will you give the same data in respect to the electro-magnet of the first single tone transmitter, parts of which you have put in evidence?

Ans. The cores of the magnet were about an inch and a half long and a quarter of an inch in diamater, the wire upon them measuring two or three ohms.

Cross-Int. 149. Was this original transmitter constructed specially for the experiments which you made with it?

Ans. The magnet was an old one, but the combination with the spring and contact screw was arranged especially for the experiments we made with it.

Cross-Int. 450. Had you, before the construction of either the first two-tone transmitter or the first single tone transmitter, seen instruments used for interrupting a current by means of a spring and a contact point arranged as they were in the two original instruments referred to?

Ans. I had.

Cross-Int. 151. Will you explain how the breaking of the short

circuit in the first single tone transmitter operated to change the strength of the magnetism of the electro-magnet of the receiving instrument?

Ans. The make and break of the short circuit operated to induce a current of electricity in the secondary wire, which charged the magnet as many times per second as the make and break occurred.

Cross-Int. 152. Were there two coils in the electro-magnet of that transmitting instrument—a primary one and a secondary?

Ans. I answered your question with reference to the two-tone transmitter. I see now that it was limited to the single tone. Speaking now of the single tone transmitter, by breaking or opening the short circuit, the entire current from the battery passed over the line through the receiving magnet, charging it strongly. When the short current was closed, a large portion of the battery current was drawn through the short circuit, leaving but a small portion upon the line, which would reduce the strength of the receiving magnet. Another effect was produced by this breaking of the short circuit—an extra current was induced upon the line, which aided in charging the receiving magnet.

Cross-Int. 153. What was the strength of the current derived from these two sources when the short circuit was broken, as compared with that arising from the battery alone when the short circuit was closed.

Ans. The instant of the break the current was much stronger than the battery current alone. The comparison I have never made.

Cross-Int. 154. What difference was there in the action of the first two-tone transmitter, when only one key was used, and the action of the single tone transmitter in producing sounds on the same receiver with the same strength of battery current?

The two-tone transmitter induced a current of electricity in the secondary wire line and receiving magnet. The single tone transmitter alternated the power of the battery current upon the line and through the receiving magnet, and induced a current also upon the line and through the receiving magnet.

Cross-Int. 155. As to the sounds produced by the receiver, what difference was there when the springs which broke the current in the two instruments vibrated at the same rate?

Ans. When the single tone transmitter was used, the reproduced tone would be louder than when one tone from the two tone transmitter was reproduced?

Cross-Int. 156. Was this difference in the loudness of the tones

due to a greater difference in one case than in the other between the maximum and minimum strength of the magnetism of the electro-magnet of the receiver during the vibration of the circuit breaking spring?

Ans. I think it was, partly, but there were other conditions which I cannot explain, but can be explained by an electrical expert; as, for instance, the matter of quickness of charge and discharge of the magnetism of the receiving magnet in the two cases.

Cross-Int. 157. In the use of these two transmitters, if I understand their operation, the change in the strength of the current, by virtue of which sounds were produced in the receiving instrument, took place when contact was made or broken between the vibrating spring and the contact point it was shown in the exhibits; am I correct in this?

Ans. That is correct.

Cross-Int. 158. Did the springs exert any influence upon the currents during their movement after their contact with the contact point was broken until they returned into contact again?

Ans. In regard to the two tone transmitter they did not; with regard to the single tone transmitter the spring did exert some influence after contact with the point was broken while approaching to and receding from the transmitting magnet.

Cross-Int. 159. You have spoken of two instruments, two single tone transmitters that were made after this first one, one of which had an induction coil and the other had not. Did these instruments operate respectively like the first two-tone transmitter when one key was used and the first single tone transmitter?

Ans. They did.

Cross-Int. 160. In your answer to the eighty-eighth interrogatory you refer to a patent, 186,340, called "Close Circuit Patent," as showing as well as another patent mentioned, a certain arrangement of batteries. If your answer is intended to convey the idea that there was a continuously closed circuit between the transmitting instrument and the receiving instrument, will you explain what the arrangement was, and state whether or not a current was continuously flowing between the transmitting instrument and the receiver?

Ans. The transmitting instruments were placed in such relation to portions of the battery that they could short-circuit said portions of battery without being themselves in the closed circuit.

Cross-Int. 161. How did this arrangement differ from that of the first single tone transmitter?

Ans. In that there was no magnet in the transmitter in this arrangement through which the current from the battery passed.

Cross-Int. 162. When was this arrangement first used by Mr. Gray?

Ans. In March, 1875.

Cross-Int. 163. State whether or not vibrating reeds were used to make and break the battery circuit, and, if so, how such making and breaking operated to effect the receiving instrument?

Ans. Vibrating reeds were used to make and break a short circuit from a portion of the battery connected with such reed in such a manner that when the reed and contact point were in contact, the larger part of the current from that portion of the battery was diverted from the line or closed circuit through the short circuit spoken of; and when said reed and contact point were separated, the current from that portion of the battery returned to the line or closed circuit, thereby alternating the effect of the current from that portion of the battery upon the line and through the receiving magnet.

Cross-Int. 164. These changes in the strength of the current passing through the receiving instrument took place at the time when the contact was made or broken between the vibrating spring and contact point, did they not?

Ans. They did.

Cross-Int. 165. And the result was, if I understand it correctly, to increase and diminish the magnetism of the core of the electromagnet of the receiving instrument at regular intervals, corresponding with the vibrations of the spring and by a constant amount?

Ans. Yes, sir.

Cross-Int. 166. At the commencement of the cross-examination I asked you to give an account of any trials which you had witnessed other than those spoken of in your direct examination of the original instruments which have been produced in evidence, or of which duplicates have been produced. Will you now give me an account of any trials which you may have seen made, beyond those spoken of in your direct examination, of instruments like the originals, or substantially reproductions of them, giving the time of such trials and the purposes for which they were made?

Ans. I used the duplicate of the two-tone transmitter experimentally in October or November, 1878, in connection with the vio-

lin animal tissue receiver or duplicate of it, the duplicate of the resonant box magnet receiver, the original concave diaphragm magnet receiver, the diaphragm box magnet receiver—using the identical one which had been put into the case as an exhibit—the wooden sounding box magnet receiver put in evidence as an exhibit with the octagon plate of iron in place of the oblong iron bar, the animal tissue revolving plate receiver put in evidence as an exhibit, and the tin plate receiver put in evidence as an exhibit. In the place of the thin plate of metal mentioned in the eleventh answer, I have used a variety of plates differing in shape from the original, but substantially a reproduction of it in connection with various transmitters, some of which trial were made in May, 1874, other in July, 1874, and other at different times from that time to the present, the purposes of such trials being, some of them experimental and others exhibitions. I have used the single tone transmitter with all the various forms of receivers, experimentally, but cannot specify particular times of particular trials, except, perhaps, in October or November, 1878, when I used it in place of the two-tone transmitter in similar experiments. The animal tissue violin receiver or duplicate of the original was used at an exhibition given in Highland Park in December, 1874, and had been used for similar purposes since that time. The animal tissue revolving plate receiver, or duplicate of it, I have seen used experimentally, but cannot give dates of such uses. A duplicate of the paper drum receiver I have seen used for receiving a telegraphic message, I think, in the winter of 1874–1875. I have seen it used at other times, but cannot give the dates. A duplicate of the resonant box magnet receiver I saw used in July, 1874, experimentally, and saw it used about the same time for receiving a telegraphic message in connection with one of the single tone transmitting instruments mentioned as having been made during that same month. I have seen it used since, but cannot give the particulars. The concave metallic diaphragm magnet receiver was used in October or November, 1878, in testing transmitting instruments, one of which was the two tone transmitter made about that time (which has been put into this case as an exhibit); also the two single tone transmitters referred to as having been made in July, 1874. A duplicate of the wooden sounding box receiver, put in evidence as an exhibit, was used in September, 1875, for reproducing melodies in connection with the transmitting instrument arranged for such transmission of melodies. One was also used for the same purpose in July, 1875, and a similar one in October, 1875, for the

2319

same purpose, and similar instruments, some of them differing a little in form, having been used at frequent intervals since that time for the same purposes; and on some of the occasions mentioned, perhaps all, a telegraphic message sent from the transmitting station was received from the receiving instrument.

Adjourned to March 27, 1879, at 10:30 A. M.

NEW YORK, March 27, 1879, 10:30 A. M.

DIRECT EXAMINATION RESUMED:

Int. 167. You said in your cross-examination (one hundred and thirty-fourth answer), "In the winter of 1874–5, in experiments with similar instruments, we were led to believe that they could be used as receivers for the human voice;" what instruments were you using and what capacity in the receivers did you notice, which led you to believe they could be used as receivers for the human voice?

Ans. We were using an instrument constructed for the purpose of transmitting melodies, similar to the one put in evidence, and marked "Gray's Two-octave Tone Transmitter," in connection with a duplicate of the resonant box magnet receiver. Some of the tones of the transmitting instrument were accompanied by a peculiar sound arising from the effect of a spark at the point of contact of the vibrating reed and contact screw. The peculiar quality of the tone at the transmitting instrument was reproduced exactly by the receiving instrument.

Int. 168. Can you name any other experiment made by Mr. Gray leading to or confirming the belief that the receiving instruments he was using for musical tones could be also used for the human voice; if so, please describe the experiments?

Ans. In experimenting with an instrument for making and breaking a battery current by mechanical means, we noticed that we could vary the quality of the reproduced tone by a duplicate of the resonant box magnet receiver by certain manipulations of the transmitting instrument. With this combination we did produce sounds very much like sounds produced by the human voice. We made a very good imitation of a groan, such as a person would produce when in pain.

Int. 169. Will you describe what manipulations you refer to, stating whether or not they were of a character to affect the condition of the current when the circuit was closed, and if so, how?

Ans. The transmitting instrument spoken of in the former answer was composed of a metallic shaft, upon which there was placed a wheel for the purpose of revolving it. Upon the shaft there were also two metallic cams, upon which rested levers of metal. Mounted under each lever was a contact screw, adjustible and so arranged that when the cut away portion of the cams reached the end of the levers the latter would drop and make contact with the screws. One battery wire was attached to one of the levers, the current passing to the screw, from that screw to the other lever, the other wire being attached to the other contact screw, so that when either was separated the battery circuit was open. One or both of the levers could be used. Rubber springs were used to vary the contact. When in use the revolving shaft would break the current a definite rate per second, and while so running, by drawing upon the rubber springs, or by pressing upon the levers with the fingers, a variable degree of contact would take place, which variable degree of contact would produce variations in the quality of the tone produced by the receiving magnet.

Int. 170. If you have it here, will you produce the apparatus you have referred to?

Ans. I do produce it.

(The apparatus produced is marked "Defendant's Exhibit Gray's Mechanical Transmitter, W. C. W., Ex'r." See p. 445.)

I will add to complete my explanation, that when one of these levers and contact points was used alone, the other lever point was cut out by a temporary wire.

Int. 171. Returning to the answer to the one hundred and thirty-fourth cross-question, where you say you and Mr. Gray were led to believe, from experiments with receiving instruments, that they could be used as receivers for the human voice. State what, if anything, Mr. Gray said, indicating such a belief on his part.

Ans. The remark was made by Mr. Gray that our receiver in use at that time was capable of reproducing the human voice.

Int. 172. Do you remember whether or not, at or about the time of your seeing the Lover's Telegraph in Milwaukee, you mentioned to Mr. Gray what you had seen?

Ans. I do not remember the circumstance at the very time, but remember speaking with him about it. There was another party with me when I saw it, who also saw it—Mr. C. H. Haskins, of Milwaukee—who probably first spoke to Mr. Gray about it.

Int. 173. In several places in your cross-examination you alluded to possible differences between original instruments used by Mr. Gray and the exhibit which you have produced here as reproductions of such instruments; do you know of any difference between any of the exhibits and the instrument it purports to represent, which in any way relates to or would affect the operation of the original instruments for transmitting and receiving musical tones, or whatever other tones you have spoken of as being produced by them?

Ans. I do not.

Int. 174. Speaking of your exhibit, which is called a duplicate of Gray's original two-tone transmitter you said in answer to one hundred and nineteenth cross-question, "probably the separate parts of this instrument are not exactly duplicates," and again, in answer to the one hundred and twenty-fifth cross-question, speaking of the Exhibit Gray's Resonant Box Magnet Receiver, you say you presume that the magnets and box are not identically like the original, as you understand the word; and again, in answer to the one hundred and thirty-first cross-question, speaking of certain other boxes which were used in connection with the single-tone transmitter, you said they were not exactly of the same dimensions as that which you have produced as a part of the exhibit; why do you speak thus doubtfully in regard to the exact correspondence of the reproductions with the originals, and state how far, if at all, you believe, as matter of fact, that there is any difference?

Ans. Because of the impossibility of making two things exactly alike with a model before you, and still more so without the original, having only a representation of it or drawing. So far as I know, there is no difference in the workings of the originals or duplicates.

Int. 175. I understand the one hundred and thirty-third cross-interrogatory to ask whether the reproduction of the tones of the single tone transmitter was the ultimate object of the apparatus in which it and the concave metallic diaphragm receiver were used together, and you answered, "At the time it was produced it was." What distinction do you make between the time it was produced and some later time? Please explain your answer.

Ans. I was not aware to what further uses it might eventually be put.

Int. 176. Do you mean to be understood that the main object of constructing and applying the concave metallic diaphragm receiver in July or August, 1874, was to receive the tones of the single tone transmitter?

Ans. I do not. It was to be used with any transmitter that we had already or might make.

W. M. GOODRIDGE.

Attest:

W. C. WITTER,
Examiner.

Adjourned to April 1, 1879, at 10:30 A. M.

NEW YORK, April 1, 1879, 10:30 A. M.

Adjourned to April 2, 1879, at 10 A. M.

NEW YORK, April 2, 1879, 10 A. M.

[Counsel for defendant puts in evidence a copy of the file wrapper, contents and drawing in the matter of the application of Elisha Gray for the patent No. 166,096, dated July 27, 1875; and the same is marked "Defendant's Exhibit Animal Tissue Application, W. C. W., Ex'r."]

Also a copy of the file wrapper, contents and drawing in the matter of the application of Elisha Gray for the patent No. 166,095, dated July 27, 1875; and the same is marked "Defendant's Exhibit Magnet Receiver Application, W. C. W. Ex'r."

Also an official copy of reissue patent No. 4558, Division A, dated January 28, 1879, granted to the Harmonic Telegraph Company, assignees of Elisha Gray; and the same is marked "Defendant's Exhibit Magnet Receiver, Reissue Art Division, W. C. W., Ex'r."

Also an official copy of reissue patent No. 8559, Division B, dated January 28, 1879, granted to the Harmonic Telegraph Company, assignees of Elisha Gray; and the same is marked "Defendant's Exhibit Magnet Receiver, Reissue Apparatus Division, W. C. W., Ex'r."

(No 54.) Defendants' Exhibit, "Deposition of William M. Goodridge (recalled)."

(Introduced by defendants in this cause) from printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd (pp. 269–278) .

J. A. W., Sp. Ex'r.

DIRECT EXAMINATION BY CAUSTEN BROWNE, ESQ., OF COUNSEL FOR DEFENDANT:

NEW YORK, May 6, 1879, 11 A. M.

Int. 1. In your answer to the eighty-ninth interrogatory, page 90 of the record, you mentioned Mr. Gray's use in September, 1875, of an apparatus having a multiple transmitter capable of sending a number of tones simultaneously, each of the volume of one tone sounded separately, and with such multiple transmitter, a receiving bar of metal opposite the poles of the magnets, as shown in the sounding-box exhibit, and with the circuit constantly closed and with the magnet constantly charged. Will you now produce one of the series of transmitting instruments constituting the multiple transmitter which was used in this apparatus, and explain the manner in which it operated in connection with the closed circuit to throw upon that circuit electrical undulations answering to the tone of the reed of each transmitter?

Ans. I produce one of the identical transmitters used. (The instrument produced is put in evidence for the defendant, and marked "Defendant's Exhibit Gray's Multiple Transmitter of 1875, W. C. W., Ex'r.") It consists of a tuned reed fastened firmly to a post mounted upon a wooden base. An electro-magnet is also mounted upon the base on each side of the reed and near the free end, supplied with adjusting screws for the purpose of adjusting the magnets a proper distance from the reed. The magnets are so connected that when the battery is applied the reed is caused to vibrate, and in so doing alternately changes the magnetic power from one magnet to the other, thereby causing a continuous vibration. On either side of the reed, about an inch from the fixed end, a light spring, of German silver with platinum at one end, is attached, opposite to which are mounted upon the base, posts which carry contact screws.

2325

There are, also, upon the base, for binding posts, two of which are used to connect the local battery causing the vibrations; the other two for connecting wires from the main battery. The contact screw and spring on the left side of the reed (that is, at my left, as I place the instrument before me with the magnets farthest from me) are in the local circuit. Those on the right are in the circuit from the main battery.

The magnet on the right of the reed is wound to one ohm resistance, the one on the left to thirty ohms. When the local battery is connected with the instrument, and the local contact screw and spring are in contact, the low resistance magnet only is in the circuit, the other or high resistance magnet being cut out by the contact of the screw and spring. The free end of the reed is immediately drawn toward the low resistence magnet, separating the contact between the local screw and spring, thereby letting into the circuit the high resistance magnet in addition to the low one. It is a well known fact that when two magnets of different resistance, other things being equal, are placed in the same circuit, and a battery current sent through them, the magnet having the higher resistance develops the stronger magnetism; consequently, the reed is drawn back towards the high resistance magnet, which immediately cuts out the high resistance magnet, and the operation is repeated a number of times per second corresponding to the natural rate of vibration of the reed. In this case the local battery circuit is never opened. For convenience of description I have lettered the different posts of the exhibit. C is the post to which the reed is fastened. I and I′ are the posts which carry the contact screws. F and F′ are the binding posts for the local battery, and G and G′ are the binding posts for the main battery connections. When the local battery is connected to the posts F and F′ the current passes from F′ to the low resistance magnet, which is the one nearest to it; through it to the post I, carrying the local contact screw; and when its contact with the spring is closed passes through the spring to the reed, through it and the post C, and from post C through binding post F, back to battery.

When the contact is broken between the post I and the reed, the current passes from the post I to the high resistance magnet (the one nearest to it) through it to the post F, and back to battery. When this instrument is attached to the main battery, the wires from the main battery are connected to the binding posts G and G′. The post G is connected with the post I′ carrying the contact screw

(No 54.) Defendants' Exhibit, "Deposition of William M. Goodridge (recalled)."

(Introduced by defendants in this cause) from printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd (pp. 269–278).

J. A. W., Sp. Ex'r.

DIRECT EXAMINATION BY CAUSTEN BROWNE, ESQ., OF COUNSEL FOR DEFENDANT:

NEW YORK, May 6, 1879, 11 A. M.

Int. 1. In your answer to the eighty-ninth interrogatory, page 90 of the record, you mentioned Mr. Gray's use in September, 1875, of an apparatus having a multiple transmitter capable of sending a number of tones simultaneously, each of the volume of one tone sounded separately, and with such multiple transmitter, a receiving bar of metal opposite the poles of the magnets, as shown in the sounding-box exhibit, and with the circuit constantly closed and with the magnet constantly charged. Will you now produce one of the series of transmitting instruments constituting the multiple transmitter which was used in this apparatus, and explain the manner in which it operated in connection with the closed circuit to throw upon that circuit electrical undulations answering to the tone of the reed of each transmitter?

Ans. I produce one of the identical transmitters used. (The instrument produced is put in evidence for the defendant, and marked "Defendant's Exhibit Gray's Multiple Transmitter of 1875, W. C. W., Ex'r.") It consists of a tuned reed fastened firmly to a post mounted upon a wooden base. An electro-magnet is also mounted upon the base on each side of the reed and near the free end, supplied with adjusting screws for the purpose of adjusting the magnets a proper distance from the reed. The magnets are so connected that when the battery is applied the reed is caused to vibrate, and in so doing alternately changes the magnetic power from one magnet to the other, thereby causing a continuous vibration. On either side of the reed, about an inch from the fixed end, a light spring, of German silver with platinum at one end, is attached, opposite to which are mounted upon the base, posts which carry contact screws.

There are, also, upon the base, for binding posts, two of which are used to connect the local battery causing the vibrations; the other two for connecting wires from the main battery. The contact screw and spring on the left side of the reed (that is, at my left, as I place the instrument before me with the magnets farthest from me) are in the local circuit. Those on the right are in the circuit from the main battery.

The magnet on the right of the reed is wound to one ohm resistance, the one on the left to thirty ohms. When the local battery is connected with the instrument, and the local contact screw and spring are in contact, the low resistance magnet only is in the circuit, the other or high resistance magnet being cut out by the contact of the screw and spring. The free end of the reed is immediately drawn toward the low resistence magnet, separating the contact between the local screw and spring, thereby letting into the circuit the high resistance magnet in addition to the low one. It is a well known fact that when two magnets of different resistance, other things being equal, are placed in the same circuit, and a battery current sent through them, the magnet having the higher resistance develops the stronger magnetism; consequently, the reed is drawn back towards the high resistance magnet, which immediately cuts out the high resistance magnet, and the operation is repeated a number of times per second corresponding to the natural rate of vibration of the reed. In this case the local battery circuit is never opened. For convenience of description I have lettered the different posts of the exhibit. C is the post to which the reed is fastened. I and I′ are the posts which carry the contact screws. F and F′ are the binding posts for the local battery, and G and G′ are the binding posts for the main battery connections. When the local battery is connected to the posts F and F′ the current passes from F′ to the low resistance magnet, which is the one nearest to it; through it to the post I, carrying the local contact screw; and when its contact with the spring is closed passes through the spring to the reed, through it and the post C, and from post C through binding post F, back to battery.

When the contact is broken between the post I and the reed, the current passes from the post I to the high resistance magnet (the one nearest to it) through it to the post F, and back to battery. When this instrument is attached to the main battery, the wires from the main battery are connected to the binding posts G and G′. The post G is connected with the post I′ carrying the contact screw

and the reed and post C are connected with the post G. In the use referred to in the question, a Morse key was placed in one or other of the wires between the main battery and the posts G or G'. When such key was closed, the current from the main battery passed to post G', from thence to the post I', and when in contact with the reed it passed through the reed and post C to the post G, and from thence to the main battery. The method of connecting the instruments with the main battery, during the use referred to in the question, is shown in the drawings of patents granted to Mr. Gray, numbered 175,971, dated April 11, 1876, No. 186,340, dated January 16, 1877, and No. 205,378, dated June 25, 1878. In the use referred to in the question, four instruments like the exhibit were connected with the main battery, at the transmitting end of the line, in such a manner that each had a definite section of the main battery. When the local batteries were connected with the transmitters, each transmitter having its local battery, and the reeds vibrating continuously and the instruments and keys (one key for each instrument) in connection with their sections of main battery, and keys all open, the current from the entire main battery was upon the line and through the receiving instrtments to the ground plate at the distant end, the other pole of the main battery being connected with the ground plate at the transmitting end, making the circuit complete. When either of the keys was closed, every time the contact screw I' and spring upon the reed of the instrument connected with said key came in contact, that section of the battery connected through that closed key with the instrument was short-circuited, thereby taken off from the line the power of that number of cells contained in said section; and when those contact points separated, the power of that section of the battery returned to the line, thereby alternating the strength of the current on the main line.

1 P. M. adjourned to 1:45 P. M.

1:45 P. M., resumed.

In addition to the above description of the transmitting instruments, I wish to say that the currents from the main battery

does not at any time pass through the magnets forming parts of such transmitters.

Int. 2. Does the apparatus contain a means of adjustment for preventing the reeds and its vibrations from touching the poles of the magnets; if so, what is it?

Ans. The magnets are supplied with screws by which they can be drawn farther from the reed or placed nearer to the reed, and firmly clamped in whatever position, with relation to the reed, they are found to work best, never being touched by the reed.

Int. 3. In his answer to the thirty-fifth interrogatory Mr. Edward S. Renwick speaks of certain experiments which he had made with what he understood to be Bell telephones, said experiments being with the sounding box or cover off the instrument or on it, with a view to ascertain practically whether the presence of the sounding box or cover had any useful effect for the purpose of distinctness or loudness of sounds transmitted or received. Did you assist in those experiments?

Ans. I did.

Int. 4. Does Mr. Renwick state correctly their character and results?

Ans. He does, so far as my observation goes. I witnessed all the experiments he made with these instruments, and tried the same experiments myself, and the results I obtained corresponded exactly with his.

Int. 5. In his answer to the thirty-ninth interrogatory he states certain experiments bearing upon the question as to the importance of the chamber in front of the diaphragm of the Bell patent of 1877, and of the mouth-piece in that patent, as to the matter of distinct and loud speaking or hearing. Did you witness or assist him in those experiments, and will you state what you can as to whether Mr. Renwick correctly gives their character and results?

Ans. I assisted him in these experiments, and also tried them myself, obtaining the same results as he describes in his answer to the thirty-ninth interrogatory.

Int. 6. In his answer to his eighth interrogatory he describes certain practical operations which he conducted in connection with others, by the use of an apparatus constructed in conformity with the specification and drawings of the Bell patent of 1876, as respects the matter referred to in the fifth claim. Did you have anything to

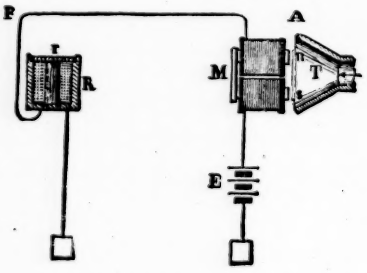
do with those experiments? If so, what? And will you state how far you are able to verify from your own observation the correctness of the account which he gives of them and of their results?

Ans. I assisted him in the experiments referred to, part of the time being at the transmitting instrument and part of the time at the receiving instrument. I did a good deal of talking and shouting into the transmitting instrument, part of the time by counting, and part of the time by sounding different tones of the diatonic scale loudly, such as the first, third, fifth and octave of the scale. I also listened at the receiving end, and heard sounds such as he describes proceeding from the receiving instrument. The results which I obtained when listening are exactly those described by Mr. Renwick, as received by him when I was transmitting.

Int. 7. In his answer to the forty-second interrogatory Mr. Edward S. Renwick says that in conjunction with you he made a number of experiments with certain common receivers, testified as used by Mr. Gray in 1874 or 1875. Will you state whether Mr. Renwick describes correctly the character and the results of those experiments?

Ans. Mr. Renwick's description is correct. I obtained on the same occasion the same results which he describes. In these experiments we were assisted by Mr. Glass, foreman of the Western Union shops, who usually did the talking while I was listening.

Int. 8. On page 881 of Prescott's "Electricity and the Electric Telegraph," I find the following account of a telephone which Prescott says was constructed by Professor Bell. The principle of his method is illustrated in Fig. 523:



"A represents the transmitting, and B the receiving apparatus. When a person speaks through the tube T, in the direction of the arrow, the acoustic vibrations of the air are communicated to a membrane tightly stretched across the end of the tube, upon which is cemented a light, permanent bar magnet, *n s*. This is in close proximity to the poles of an electro-magnet M, in the circuit of the line, which is constantly charged by a current from the battery E. The vibrations of the magnet *n s* induce magneto-electric pulsations in the coils of the electro-magnet M, which traverse the circuit; and the intensity of these pulsations is in proportion to the vibrations of the magnet. Consequently, this apparatus is capable of transmitting both the pitch and intensity of the tones which enter the tube T. The receiving instrument consists simply of a tubular electro-magnet R, formed of a single helix with an external soft iron case, into the top of which is loosely fitted the iron plate R, which is thrown into vibrations by the action of the magnetizing helix." How does the apparatus here described and represented compare with the telephone which Mr. Bell exhibited at the Philadelphia Centennial?

Ans. I witnessed the experiments made in Philadelphia on the 25th of June, 1876, by Professor Bell, and saw the apparatus described in the passage you have quoted. I consider the cut a fair representation of the instrument I saw. My impression of the receiving magnet is that it was somewhat longer in comparison with its diameter than the cut showed it to be; also, that the tube T, as I remember it, was considerable longer than it is represented in the cut. I should say the tube I saw was about six inches long.

Int. 9. In the apparatus described and shown in the passage I have read from Prescott's book, is the external soft iron case at the receiving end in magnetic connection with the core, so as to be magnetized as well as the core by the passage of the current through the coil?

Ans. As I understand it, it forms one pole of the magnet, of which the central core forms the other pole; consequently, it must be in magnetic connection with the central core.

Int. 10. You stated on your former examination that a sounding box, like that which makes part of the "Exhibit Gray's Resonant Box Magnet Receiver," was sent to Washington as a model, accompanying his application for his original magnet receiver patent. Of what material was this sounding box, which went to the Patent Office, made?

Ans. It was made of what is commonly called tin plate, said plate being thin iron, plate coated with tin.

Int. 11. I do not remember that it has been testified of what material the concave metallic diaphragm receiver, made in Chicago in July, 1874, was made. Please state?

Ans. The concave metallic diaphragm was also made of sheet iron, coated with tin.

Int. 12. In one of the extracts which have been put in evidence from Professor Bell's London lecture, describing an apparatus such as is represented by Fig. 7 of his patent of March, 1876, he says that the diaphragms were made of goldbeater's skin; please to state, if you know, what the character of this material is, its degree of thinness and of sensitiveness to moisture, as compared with the material of which the diaphragms are made in the Defendant's Exhibit Bell Apparatus of 1876, patent?

Ans. Goldbeater's skin is a very thin animal membrane. How it compares in thickness with the diaphragms in Defendant's Exhibit Bell Apparatus of 1876 patent I do not know exactly, but should think it was three or four times thinner, on account of its thinness. I think it is very much more sensitive to moisture than the parchment used in the exhibit spoken of. When the instruments were first made, which are in this case as exhibits, and marked respectively "Defendant's Exhibit Bell's Apparatus of 1876, Patent Receiver" and "Defendant's Exhibit Bell Apparatus of 1876, Patent Transmitter," the diaphragms were made of goldbeater's skin. When placed upon the cones they were moistened and stretched tightly, and wired so that they could not slip off, when dry they were very tight and tense. After standing a little while in a warm room, I found both of the diaphragms had burst, and was obliged to put on new pieces. This was done in Chicago. When they arrived in New York I found they had burst again. I then procured the parchment of which the diaphragms now on the instrument were constructed, and had them mounted as they now are at the shop of the Western Union Telegraph Company. These latter diaphragms retained their elasticity longer than the former thin ones did; or, in other words, you can use the transmitter a much longer time before the diaphragm is affected by the moisture of the breath and becomes flabby.

2351

CROSS-EXAMINATION BY J. J. STORROW, ESQ., OF COUNSEL FOR COMPLAINANTS:

Cross-Int. 13. Where were you from the first of May, 1874, until you went abroad in August of the same year?

Ans. In Chicago, with an occasional little run into the country.

Cross-Int. 14. Did you come East during that time?

Ans. I did not.

Cross-Int. 15. Look at the tenth question and answer in your deposition of to-day. Have you any personal knowledge that what is there called the sounding box was ever filed in the Patent Office?

Ans. I have not.

Cross-Int. 16. The Mr. Prescott spoken of in the eighth question and answer of to-day's deposition is the same Mr. Prescott spoken of in Mr. Gray's seventy-second, seventy-fourth and seventy-eighth cross answers, pages 130 and 131 of the printed record, is he not?

Ans. I so understand it.

Cross-Int. 17. The apparatus of Professor Bell, which you referred to in your eighth and ninth answers of to-day's deposition, is the same as that referred to in Mr. Gray's fifty-third answer, page 126 of the printed record, is it not?

Ans. Yes; that is the same.

Cross-Int. 18. Is the description of the small circular plate of iron or steel, and of its relation to the iron tube and core of the tubular magnet receiver of Professor Bell, which is found in that answer of Mr. Gray, correct according to your recollection?

Ans. It is.

Cross-Int. 19. Look at your twelfth answer of to-day's deposition. Did you personally attach or see any one else attach the membranes which you say were mounted at the shop of the Western Union Telegraph Company in New York?

Ans. I did not. I told them how to do it, and left it for them to do.

Cross-Int. 20. I understand from your first answer in to-day's deposition that the function and effect of the local battery of each transmitter, when they are all connected up in the manner described in that answer, is to cause the reed to vibrate, and that the curren

from that local battery does not ever pass over the main line to the distant station. Am I correct in this?

Ans. That is correct.

Cross-Int. 21. I understand from that answer, and particularly from that passage in the latter part of it, which transcribes what takes place when the key of any particular transmitter is closed, that when in the course of the vibration of the reed, caused by the action of the local battery contact is made between the reed and the contact screw I′, the current from those cells of the battery which are appropriated to that particular transmitter passes through that contact and through a short circuit back to the other end of those cells, instead of being forced to over the main line. Am I right in that?

Ans. The bulk of the current is so diverted from the line through the short circuit when the reed and contact screw I′ are in contact. A small portion, however, is still upon the line.

Cross-Int. 22. The amount which is thus diverted, and which you call the bulk of the current as compared with the small amount which passes over the line, depends upon the comparative resistance of the passage of the electricity offered by the short circuit, when that is completed by closing the contact in the manner spoken of in the last question, and the resistance of the long circuit over the line through whatever apparatus may be connected up as part of it at the distant station, and back through the earth to the battery. Is this so?

Ans. It is.

Cross-Int. 23. When the reed in this transmitter vibrates over the other side of its path, so as to break contact between the contact screw I′ and the reed spring, the short circuit is broken or opened, and this amount, which you call the bulk of the current, instead of going through the short circuit, as in the case stated in the twenty-first cross-question, is forced to go over the line to the distant station and through the receiving instruments, which are there connected up in the line, and thence back through the earth to the battery. Is this so?

Ans. That is so.

Cross-Int. 24. That amount of current, which you call the bulk of the current, and the amount of which is determined by the relation of the resistances, as stated in the twenty-second cross-question and answer, is alternately thrown through the line and receiving instrument at the distant station, or diverted from the line and receiv-

2333

ing instruments each time the reed of the transmitting instrument in its vibration breaks and makes the contact with the contact screw I′, when the instruments and apparatus are used and connected up in the manner described in your first answer of to-day's deposition. Is it not so?

Ans. As I understand the question, that is so.

WM. M. GOODRIDGE.

Attest:

W. C. WITTER,
Examiner.

Adjourned to May 7, 1879.

from that local battery does not ever pass over the main line to the distant station. Am I correct in this?

Ans. That is correct.

Cross-Int. 21. I understand from that answer, and particularly from that passage in the latter part of it, which transcribes what takes place when the key of any particular transmitter is closed, that when in the course of the vibration of the reed, caused by the action of the local battery contact is made between the reed and the contact screw I′, the current from those cells of the battery which are appropriated to that particular transmitter passes through that contact and through a short circuit back to the other end of those cells, instead of being forced to over the main line. Am I right in that?

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2333

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Ans. As I understand the question, that is so.

WM. M. GOODRIDGE.

Attest:

W. C. WITTER,
Examiner.

Adjourned to May 7, 1879.

2334

(No. 54b.) "Deposition of Elisha Gray." (Introduced by defendant in this cause, from Printed Record, Bell Telephone Company et al. vs. Peter A. Dowd, pp. 111-156.)

J. A. W., Sp. Ex'r.

DIRECT EXAMINATION BY CAUSTEN BROWNE, OF COUNSEL FOR DEFENDANT:

Int. 1. What is your name, age, residence and occupation?

Ans. Elisha Gray; I am forty-three years old; I reside at Highland Park, Illinois, and am a professional electrician and inventor.

Int. 2. You are the person to whom the patents to Elisha Gray, put in evidence for the defendant in this case, were granted?

Ans. I am.

Int. 3. Did you see in Boston the telephones produced as Exhibits, representing instruments used by the defendant Dowd, and for which use this suit is brought as an infringement of the Bell patents?

Ans. I did.

Int. 4. Of whose manufacture are the instruments used by Mr. Dowd?

Ans. They were made by or on the order of the American Speaking Telephone, of New York.

Int. 5. Is that company's manufacture of telephones conducted under license from the owners of your patents put in evidence in this case, so far as such patents are applicable to telephones?

Ans. Yes, sir.

Int. 6. Mr. Goodridge has testified in this case to transactions in regard to your inventions, beginning with his employment by you in the early part of 1874; will you please state how long before that you had been occupied more or less with studies, experiments and practical inventions relating to electric telegraphy, particularly noting anything relating to the telegraphic transmission of sounds, and give a brief account of your doings in connection with these subjects?

Ans. At a very early age I was interested and read everything I could obtain relating to the physical sciences, but more especially

2335

the science of electricity and magnetism. It was my habit to construct and operate any machine I saw described, so far as my facilities would allow. I remember having constructed telegraphic instruments, electro-magnets, galvanic batteries, of various forms; all of which operated successfully a long while before I became a professional electrician. About the year 1865 the opportunity offered that I long sought to become engaged professionally as an electrician and inventor. In the winter of 1866–7, while experimenting upon an improvement in telegraphic relays which were patented in the fall of 1867, I made my first observation relating to the transmission of musical tones or sounds telegraphically. The apparatus I then used consisted of an induction coil of ordinary construction, having a vibrating electrotome. In the primary circuit there was a battery and an ordinary Morse key. In the secondary circuit, in which was included a short line, was placed an instrument known as the polarized relay, which operates by to and fro currents. When the key was closed the electrotome was thrown in vibration, producing a sound or tone more or less musical, and this tone or sound was reproduced on the receiving instrument (the polarized relay) before mentioned. At this time I also conceived the idea of constructing an instrument for transmitting tunes, similar to its general aspects to instruments made at a later date. From this time till about the beginning of 1874, I was constantly engaged as an inventor of electrical appliances, generally relating to improvements in telegraphic apparatus. All the inventions I made during this time I cannot now recall, as many were never patented. I can name, however, patent for self-adjusting relay, granted in the fall of 1867; another, April 14, 1868, for what is known as the induction relay. After that I invented and constructed several forms of telegraphic repeaters, dial-telegraph instruments, a printing telegraph instrument which has been and is extensively employed by the Gold and Stock Telegraph Company. I also invented and patented an electric hotel annunciator, now in very general use. I was also first inventor of what is known as the Travelling Annunciator, used in elevators. I invented and patented the telegraphic station-switch, which is in very general use.

Int 7. When did your residence in Chicago begin?

Ans. About November or December, 1869.

Int. 8. Mr. Goodridge has testified that in the early part of 1874 you were the superintendent of the Western Electric Manufacturing Company, of Chicago; when did you take that office?

Ans. I took the office at the time the company was organized; I think in the year 1872, about May.

Int. 9. What was the nature and extent of the business which that company carried on during your superintendence.

Ans. We were manufacturers of all kinds of electrical and telegraphic instruments, and dealers in telegraphic supplies. At the time the company was organized, we employed from twenty-five to fifty men, I cannot give the exact number, but the business rapidly increased, so that in 1874 we were employing about one hundred men, more or less. It was, and has been till now, about equal to the Western Union shops in New York in extent. At the time of its organization it is larger, I think.

Int. 10. Mr. Goodridge has produced an instrument which is marked "Defendant's Exhibit Gray's Two-Tone Transmitter," which he says represents an instrument he made by your direction in April, 1874, at Chicago, and described the manner of connecting it up and using it for the purpose of transmitting two tones simultaneously or singly over a telegraphic circuit. Do you remember the original instrument?

Ans. I do.

Int. 11. Have you read Mr. Goodridge's deposition?

Ans. I have.

Int. 12. Is his description of the instrument just referred to, and the manner of its use, correct?

Ans. It is.

Int. 13. Mr. Goodridge also describes an instrument which was made by him under your direction after the two-tone transmitter, and which was an instrument for transmitting one tone, and is said by him to be represented by Exhibit Gray's First Single Tone Transmitter, parts of which are parts of the original instrument; and he describes the manner in which it was set up and used in circuit for the purpose of transmitting its tone. Is the original instrument correctly described by him, and the exhibit just mentioned a correct representation of it as stated by him, and was it used as described by him at the time stated?

Ans. Yes.

Int. 14. In answer to the twentieth interrogatory of his deposition, Mr. Goodridge describes a number of receiving instruments as having been used by you or under your direction in Chicago; namely, an animal tissue receiver under three different forms, a paper drum receiver, a magnet receiver with a hollow tin box placed

2337

on or near the poles, a concave metallic diaphragm receiver, a magnet receiver having the magnets inclosed in the box, and a magnet receiver consisting of an iron plate mounted upon a sounding box. Do you remember these instruments, and are they correctly described by Mr. Goodridge?

Ans. I remember them, and they are correctly described, so far as I recollect. The one described as an iron plate, mounted upon a sounding box, had also an electro-magnet.

Int. 15. First, as regards the use of the several forms of animal tissue receiver and the paper drum receiver, as used in Chicago with the assistance of Mr. Goodridge, before you went abroad in August, 1874; is Mr. Goodridge's account of such use of the instruments correct?

Ans. It is.

Int. 16. Mr. Goodridge also describes the use in Chicago, before you and he went abroad, of the first single tone transmitter in a closed circuit, and with the magnet receiver, consisting of the hollow tin box, placed on or near the poles of the magnet; his description being contained in his twenty-ninth to thirty-third answers. This use, he says, was at the works of the Western Electric Manufacturing Company. Do you remember the use referred to?

Ans. I do. I cannot give the time as to the month; it was before going abroad, however.

Int. 17. Does Mr. Goodridge describe the place and conditions and results of that demonstration correctly?

Ans. Yes, sir.

Int. 18. In his thirty-fifth and thirty-sixth answers Mr. Goodridge describes the use at the works of the Western Electric Manufacturing Company before you went to Europe, of the concave metallic diaphragm receiver with its first single tone transmitters working over a closed circuit. Do you remember such a use before you went abroad in 1874?

Ans. I do. I am not sure whether it was with the first single tone transmitter, or one which they subsequently made like it.

Int. 19. State, if you know, who witnessed this use and who was at the receiving end and who at the transmitting end?

Ans. I cannot tell definitely who, beside myself and Mr. Goodridge, were present. I was at the receiving end, Mr. Goodridge at the transmitting end a portion of the time. The order was reversed at times, to give Mr. Goodridge chance to observe the results at the receiving end. The experiments were openly conducted, and

a number of persons might have witnessed them. I am very sure that Mr. E. M. Barton, Mr. M. G. Kellogg, and, I think, Mr. Earnest Warner were present at some of those experiments.

Int. 20. Mr. Goodridge has described, in his testimony, two multiple transmitting instruments—a single octave and a double octave—as made for you in Chicago, in 1874, before you went abroad, and used in connection with the resonant box magnet receiver and the concave metallic diaphragm magnet receiver, with the closed circuit, at Chicago, before you went abroad. Is the description given by Mr. Goodridge, of the manner in which these trrnsmitters were constructed and the manner they were used in connection with the receivers mentioned, correct?

Ans. It is.

Int. 21. Mr. Goodridge refers, in his deposition, to an exhibition made in July, 1874, of the two octave transmitter with a resonant box receiver and the concave metallic diaphragm receiver, in Chicago, between the office of General Stager, Superintendent of the Western Union Telegraph Company, and the works of the Western Electric Manufacturing Company, the two stations being about three-quarters of a mile apart, the receiver being at General Stager's office and the transmitter at the other end. Mr. Goodridge was, he says, at the transmitting end on this occasion. Do you remember the trial referred to; if so, what did you have to do with it, if anything?

Ans. I distinctly remember the trial, and I conducted the exhibition at the receiving end. We used the concave metallic diaphragm receiver, but I am not sure as to the use of the resonant box on this occasion.

Int. 22. State the character of this exhibition, whether public or private; and by how many persons was it witnessed, so far as you know?

Ans. It was public, in the sense that any one was privileged to witness it; and during the exhibition several persons from outside were invited in, besides a number of the employees about the building.

Int. 23. Please state the character of the results obtained upon that trial as to loudness and distinctness of tones heard, and otherwise?

Ans. The results were satisfactory in every respect. A number of tunes were transmitted which could be heard and recognized in any part of the room without the least difficulty.

2339

Int. 24. I understood you to say that you were not sure that the resonant box magnet receiver was used on that occasion. Do you remember any occasion on which it was used for the purpose of exhibition with the key-board transmitter, whether single or double octave, and in a closed circuit as before, in Chicago, before you went abroad, in 1874?

Ans. It was used a number of times in connection with the key-board transmitter on our experimental wire at the shop.

Int. 25. Did you, before going abroad in August, 1874, take from Chicago to the City of New York any af the instruments mentioned by Mr. Goodridge, for the transmission of musical tones, and exhibit there such instruments and their operation?

Ans. I did.

Int. 26. What instrument did you take and exhibit there?

Ans. The single octave transmitter, the resonant box magnet receiver, the original violin animal tissue receiver and the paper rum receiver; that is all I remember.

Int. 27. What time in 1874 was this?

Ans. It was in the early part of May that I first exhibited them in New York; the exhibition extended through ten days or two weeks.

Int. 28. Had your concave metallic receiver been made at this time?

Ans. No, sir.

Int. 29. In what place or places in New York did you give the exhibition you speak of?

Ans. First, at the office of the Gold and Stock Telegraph Company, 61 Broadway; secondly, at what was then the Western Union Telegraph Building, 145 Broadway.

Int. 30. Please describe the manner in which these exhibitions were conducted, as to the distance apart of the transmitting and receiving stations, and other conditions bearing upon the question of the capacity of the instruments for distinct transmission of musical tones?

Ans. Ordinarily the exhibitions were conducted between two rooms in different parts of the building or buildings by a wire connecting one with the other. The rooms were so situated with reference to each other that the noise of the transmitters could not be heard at the receiving end, except upon the receiving instrument connected in circuit. On two or three occasions, or perhaps more, we made a long line by means of looping two wires together in a

distant city, which gave us the two terminals in the same building. The results were satisfactory under all the conditions mentioned, in the matter of clearness and loudness of tone at the receiving end.

Int. 31. Please describe a little more fully what you refer to as making a long line by means of looping two wires together in any distant city?

Ans. In one instance we used two wires to Boston, connected in the following manner: starting from the ground in New York, one wire passed first through the transmitting instrument, and from thence to Boston, when it was disconnected from the ground and connected to the end of another wire (also disconnected from the ground in Boston), which ran back to New York, fastened through the receiving instrument and from thence to the ground, making a length of line double the distance from New York to Boston.

Int. 32. In working with the looped line around Boston, in what building in New York were the two terminals, and in what parts of that building respectively?

Ans. In the Western Union building before mentioned, 145 Broadway. One terminal was in the room with the transmitter, the other in the room with the receiver, the two rooms being those previously mentioned in my thirtieth answer.

Int. 33. I have understood from your answers that this demonstration with the looped line around Boston, or another distant city, took place in May, 1874; was it so?

Ans. It was.

Int. 34. Were the instruments connected up and worked in a constantly closed circuit, in the exhibitions which took place in New York in May, 1874?

Ans. They were worked there as everywhere. As Mr. Goodridge explained, the transmitter was made on the plan of what is called the single tone transmitter. For convenience of operation, when the keys were up the line was opened, but when any key was depressed, the running of the circuits during the continuance of the transmission of any tone was precisely the same as shown in the exhibit marked "Gray's Closed Circuit, Single Tone Transmission Apparatus," so that the actual operation during the transmission was the same in both instruments.

Int. 35. Referring particularly to the use (in these New York exhibitions) of the resonant box magnet receiver, state whether it

was used resting upon the poles of the magnet, or slightly removed from them, or in both ways?

Ans. It was used in both ways.

Int. 36. When slightly removed from the magnet poles, was it supported in that position in the same way that Mr. Goodridge described, as to its use in that manner in Chicago?

Ans. It was.

Int. 37. Was there any difference in the loudness or distinctness or quality of the received tone, according as the resonant box receiver was resting upon the poles or slightly removed from them? If so, state?

Ans. Ordinarily there was a difference in favor of slightly removing the resonant box either from one or both poles. I will state further, that the difference was very slight in some positions of contact, as to the matter of loudness and quality. For instance, if the box were slightly tipped, as was a common way of using it, so that the bearing was on the edge of the poles, the result would ordinarily be better as to loudness than when flat upon the poles. This, however, was not always true, for I could get the same good results by simply turning the box around on the face of the poles. I have always supposed this to be due to the fact that the face of the box in contact with the poles was not perfectly even, although such unevenness could not be detected by the naked eye.

Int. 38. Will you name such persons as you can who witnessed the exhibitions in New York which you have described?

Ans. Of those now living I will name, at 61 Broadway, I remember Mr. Applebaugh, Mr. Scott, now Superintendent of the Gold and Stock Telegraph Company, Mr. R. Henry, Mr. Wiley, and many others. At 145 Broadway, General Thomas T. Eckert, Mr. Chandler, Superintendent of the Atlantic and Pacific Telegraph Company; Mr. S. Brown, District Superintendent of the Western Union Telegraph Company; A. S. Downer, Manager of the Operating Room Western Union Telegraph Company; G. M. Phelps, Superintendent of the Western Union Telegraph Company's shops; Mr. Phelps, Jr., of the same shop. Most of the Directors and the Executive Committee of the Western Union Company were present at one of the exhibitions, in a body, and many others.

Int. 39. Did you make similar exhibitions with the same apparatus in other cities than New York, before you returned to Chicago, that spring?

Ans. I did. I exhibited in Washington City, in presence of

Prof. Henry, at the Smithsonian Institute, on two or three occasions. At one of these, Prof. Warson, of Ann Arbor, Prof. Hall, of the Naval Observatory, Washington, and others were present. I also exhibited between two rooms in a building on the corner of Fourteenth street and Pennsylvania avenue, then occupied by the Western Union Telegraph Company. There were present at these exhibitions a number of persons at different times, among whom was Mr. Elliot, the Chief Clerk of the Treasury Department Bureau of Statistics; Mr. A. L. Hayes was present. These are all the names I can recall now.

Int. 40. You have read Mr. Goodridge's description of the instruments which were carried abroad by you and him in August, 1874, and sent back to this country in the following October, and of the places in which, the manner in which and the persons to whom they were exhibited while in England. Is his description correct?

Ans. Correct. I will add that Mr. Goodridge was chiefly at the transmitting end, and could not swear to all that I could.

Int. 41. Were all the receivers which were carried out exhibited at one time or other in circuit with the multiple transmitter during your stay in England?

Ans. They were.

Ins. 42. It appears, by Mr. Goodridge's deposition, that the apparatus which was taken out to England by you was sent back to this country through the Custom House, and there detained for some reason, so that they did not come into his possession again until the fall of 1875. Will you explain the reason of this detention in the Custom House, so far as you could ascertain, and also all the efforts you made to get the apparatus out of the Custom House sooner than you succeeded in doing?

Ans. The instruments taken abroad were for a particular purpose, and not designed to be left there; and it was expected that they would be returned free of duty. When we sailed for this country in October, 1874, the instruments were left in charge of Warden, Muirhead & Clark, to be shipped to us at New York. I was not familiar with the rules of the Custom House in the matter of shipping goods from a foreign port to this country, and so left the matter with the before mentioned gentlemen, who were constantly shipping and were supposed to know all about it. After landing in New York I waited three or four weeks for the arrival of the instruments, as I was very anxious to make some exhibitions before going West. After waiting a long time—I do not now remember just how

long—I was notified by Morris & Co., foreign express agents, of the arrival of the goods. I went to procure them, but could not get them released from the Custom House, because no invoice had been sent. I was obliged to write to Warden, Muirhead & Clark to obtain the invoice; but not having the goods, they did not know how to make it out. And when, finally, I obtained either the invoice or shipping receipt, I cannot tell which, it did not have the proper consular's certificate attached. This was followed by considerable correspondence, both with the express agents and the shippers, and others, trying to find out what to do and how to do it. I went to a Custom House agent to have him look the matter up and offered to pay the duty; but for some reason I was unable to get the apparatus. I employed two different parties; finally got a friend of mine to see the Superintendent of the Custom House, and find out what the trouble was. He did not succeed; neither could he tell me how to proceed to get the goods. The result was, that after a lapse of time—about a year, I think—they were sold for duties I suppose, and I bought them of the party who bid them in at the sale.

Adjourned to April 3, at 10.30 A. M.

NEW YORK, April 3, 1879, 10.30 A. M.

Int. 43. You have read Mr. Goodridge's testimony as to transactions after you and he returned from Europe, including apparatus made for you and the use of the same, and the manner and results of such use. Do you confirm his testimony as true as far as it states matters with which you were connected? Pointing out what matters, if any, stated by him were not within your personal knowledge?

Ans. I do, with the following qualifications: Mr. Goodridge states, in answer to the sixty-fourth question of his direct examination, that there were two resonant box magnet receivers made. My recollection as to the disposal of that (that is, the two referred to by him) coincides with his, but I remember that we used one in Chicago on numerous occasions between the middle of June and the middle of July, 1874. That would seem to account for three. In the experiment referred to by Mr. Goodridge, in answer to the

seventy-ninth direct question, I was at the receiving end, at Milwaukee, and Mr. Goodridge at the transmitting. In regard to the apparatus and its use mentioned in the eighty-ninth answer, the first use that I distinctly remember was in September, 1875. I remember such use was made at an earlier date and at different times, but I cannot exactly locate any experiment. The experiment mentioned by Mr. Goodridge in his ninty-ninth answer I did not personally witness. I did witness similar experiments at a subsequent time. In regard to the experiments mentioned by Mr. Goodridge as conducted under the direction of Mr. Edward S. Renwick, I was there only a part of the time. I witnessed some of the experiments made with my different receivers, particularlly the resonant box magnet receiver.

Int. 44. I will call your attention particularly to the trial which Mr. Goodridge mentions as having been made upon a telegraph line between Chicago and Milwaukee, near the middle of February, 1875, in which trial you were at the receiving station. State what receiver or receivers were used upon that trial?

Ans. I used the receiver called the "Diaphragm box magnet receiver."

Int. 45. Can you name any persons who witnessed this trial at the receiving station? And state whether it was a private or a public exhibition, and state the character of the results obtained?

Ans. Mr. C. H. Haskins, superintendent Northwestern Telegraph Company; Mr. Weller, manager of the Western Union Telegraph Company at Milwaukee; Mr. Kelsey, chief operator Northwestern Telegraph Company; Mr. Shape, chief operator Western Union Telegraph Company, Milwaukee; and a number of others were present. The exhibition was in Mr. Hasken's office and was open to any one. The design of this particular experiment was to test the ability of the tones to travel over a long line. The result of the experiment was satisfactory, and we were able to receive messages by means of the before mentioned diaphragm box magnet receiver, which received musical tones instead of the ordinary Morse dot and dash; the duration of and intervals between the musical tones corresponding to the arbitrary signs of the well known Morse alphabet.

Int. 46. When did you first see the instrument sometimes called the "Lover's Telegraph," and where? And state by what name it was then called. I refer to the instrument which was described as the "Lover's Telegraph" in Mr. Goodridge's deposition?

Ans. In November or December, 1875, at Milwaukee; I do not remember any name given it at that time; I remember the description of it as first given to me by Messrs. Goodridge & Haskins, as both were present when it was described, and a few days later I saw it.

Int. 47. Will you now state what, if anything, you had observed in your uses of different tone transmitters, in 1874 or 1875, which showed to you the capacity of your resonant box receiver or diaphragm box magnet receiver, or concave metallic diaphragm receiver, to receive and reproduce to the ear the quality as well as the pitch and loudness of the transmited tone.

Ans. The first experiment I remember which attracted my attention particularly to the fact that the quality as well as the pitch and loudness could be transmitted electrically through a telegraphic circuit and received upon a common or universal receiver, was in the latter part of January or the fore part of February, 1874. I refer now to what is known as the "bath-tub experiment." I was then using an ordinary induction coil, having a vibrating electrotome, and I was receiving the vibrations transmitted through the secondary circuit through my body, the other pole of the coil being connected with the zinc lining of the bath tub, which was dry at the time. When I rubbed the tub lining with my fingers or the palm of my hand, the noise made by the vibrator was faithfully reproduced at the point of contact, as I was near enough to the transmitting instrument to hear it, and was thus able to make a comparison. I made numerous changes in the adjustment of the electrotome, getting a great range of vibratory effects, producing sounds (not very musical ones) of great variety of quality. The fact that these were all faithfully reproduced demonstrated to me at that time that quality as well as pitch could be transmitted electrically. I observed the same thing in all my later experiments during the years 1874 and 1875.

I will refer now to an experiment made in 1875 with the transmitter marked "Gray's Mechanical Transmitter," in connection with one or more of the common receivers or their duplicates that had been described by Mr. Goodridge. When the transmitter referred to had one of its vibrating great points placed in circuit in which was the battery and the common or universal receiver, and the shaft which actuated the break point was revolved steadily, there was a sound of a peculiar quality reproduced at the receiving end on the common receiver. This quality was greatly varied by grad-

uating the pressure, either by the finger or by a rubber spring upon the lever carrying the break point, so that by proper manipulation with reference to pressure, we obtained a great variety of sounds on the receiver, not unlike the human voice, imitations of vocal sounds, and also imitations of a groan as if in distress, were very perfectly and reproduced. It was our custom in all such experiments to use the different varieties of receivers, to notice the different effects produced on each. I cannot recall clearly whether all were used at that time or not; but I remember that more than one form, among which was the wooden sounding box receiver and the resonant box magnet receiver.

Int. 48. Mr. Goodridge, in his one hundred and sixty-eight answer, spoke of this observed operation of the mechanical transmitter as leading to or confirming the belief that the receiving instruments you were using for musical tones could be also used for the human voice; what was your own judgment at that time upon that subject?

Ans. This experiment with the mechanical transmitter confirmed what my previous experiment had led me to believe that not only could the receivers that had been named be used as receivers of articulate speech transmitted electrically, but that such speech could be transmitted through or from a single point. I mean by single point, without the intervention of a series of reeds of points differently tuned, and one that would be a common or universal transmitter, in the same sense that the receivers were universal or common.

Int. 49. Will you state how the knowledge which you got late in 1875 of the so called "Lover's Telegraph," aided in the production of the invention of a speaking telephone, such as is described and represented in your caveat filed February 15, 1876?

Ans. The fact that all the vibrations, however complex or different in form, that are produced in uttering any given word or sound, were transmitted longitudinally through a fine thread suspended from the center of a diaphragm capable of responding to all the aerial vibrations made by the uttering of a word or sound, and connected to a similar diaphragm at the other end of the thread, which might be from one to two hundred feet in length, proved to my mind that all the conditions necessary for the transmission of an articulate word were contained in any single vibrating point capable of responding, as before stated. I saw that if I could reproduce electrically the same motions that were made mechanic-

ally at the centre of the diaphragm by speaking upon it, such electrical vibrations would be reproduced upon a common receiver in the same manner that musical tones were; and from the fact that the electrical vibrations were the same in respect to rate, amplitude and form or complexity, as the motions made in the air by uttering words or sounds, it followed that the receiving diaphragm would be thrown into mechanical vibrations or motion of a corresponding character, and consequently reproduced the same word or sound. The fact that the longitudinal movement (in water or other fluid of poor conducting character) of a wire or some good conductor of electricity, with reference to another wire or metal conductor, produced variations in the resistance of an electric circuit proportional to the amplitude of movement, was old in the art of that time; so that the last link of knowledge necessary to solve the problem in my mind was furnished in the capabilities of the longitudinal vibrations of the string of the before-mentioned so-called Lover's Telegraph.

Int. 50. At the time of your filing your caveat, February 14, 1876, had you ever seen or heard of any apparatus for the telephonic transmission of articulate speech other than that which you described and represented in that caveat?

Ans. I had not.

Int. 51. When did you first have knowledge of Professor Bell's invention of a telephone or apparatus for telegraphic transmission of articulate speech?

Ans. I think the first knowledge that I obtained was from a lecture delivered by Professor Bell in Boston some time in the spring of 1876. A printed copy of that lecture was sent me by some one, and I am not now sure whether I received that copy before Professor Bell's exhibition at the Centennial or not. If not, the first I knew of it was at the Centennial or about that time.

Int. 52. Was the instrument described in that lecture the same as that which Professor Bell exhibited at the Centennial?

Ans. There were no drawings accompanying that lecture, as I remember it, and I do not think I had an intelligent understanding of the apparatus until I saw it at the Centennial Exhibition.

Int. 53. Will you describe the apparatus which you saw at the Centennial Exhibition?

Ans. The transmitting portion of the apparatus that I saw consisted of a vocalizing chamber very similar in form to the chamber

of the receiver shown in my caveat. Across the large end of the chamber was stretched a membranous diaphragm. Upon the center of this diaphragm was glued a thin plate of iron or steel, I should think about three-eights of an inch wide and from an inch and a half to two inches long. In front of this armature or plate was mounted, in a frame connecting with the vocalizing chamber, an electro-magnet having a fixed relation to the armature or plate, but not touching it. The receiver, as I recollect it, was made of a single bobbin or helix having an iron core in the centre and an iron tube on the outside, which was closed at one end, having the iron core fixed in the centre projecting up through the helix. A small circular plate of iron or steel was placed upon the other end, so that its edges rested upon the outer cylinder or tube of iron, while its centre was over the central core, and, I think, not in contact. About the latter I am not sure. I understood from Professor Bell's description that the two instruments were connected in circuit, in which a battery was included, in the same manner that any two ordinary telegraphic instruments would be connected in circuit. This was the arrangement as to instruments and connections, to the best of my recollection at this date.

Int. 54. When I asked you as to your first knowledge of Professor Bell's invention of the telephone I had reference to an actual working apparatus. Did you understand me?

Ans. Not exactly. I thought you wanted to know when I first heard of anything that he had done in that line.

Int. 55. I suppose you knew some time earlier than that of what was contained in the specification and drawings of his patent of March 7, 1876?

Ans. I did.

Int. 56. Was this apparatus which you saw at the Centennial the first one you ever saw in which an induction diaphragm was used in combination with an electro-magnet as a telephone transmitter?

Ans. It was.

Int. 57. Was such combination for the purpose of a telephone transmitter new with Professor Bell, so far as you know?

Ans. It was, so far as I know.

Int. 58. Please state which of the various receivers which have been testified to as used by you in 1874 and 1875 was best adapted for receiving and giving out audibly tones of the human voice?

Ans. The concave metallic diaphragm magnet receiver was per-

haps in some respects the best; but there is very little difference between that and the diaphragm box magnet receiver, and also the resonant box magnet receiver.

Int. 59. Please state how you were occupied in the year 1876, and down to October, 1877, stating what, if any, experiments or investigations you made during that time relating to telephones, as distinguished from telegraphic apparatus proper, and so far as you did not, explain why not?

Ans. About the 15th January, 1876, I went to Washington for the purpose of preparing and filing in the Patent Office a number of cases relating to telephony that had been accumulating through a number of months. I remained there till about the first of March. From thence I went to Philadelphia, partly to prepare for the Centennial Exhibition and partly for the purpose of exhibiting my apparatus relating to multiple telegraphy to parties who were proposing to invest in it. I remained there during the spring months, but was called home early in June on account of sickness in my family. I returned a few days previous to the exhibition given by myself and Professor Bell at the Centennial on the same day. I was engaged from the time till after the 4th of July with my exhibit at the Centennial. During this period Mr. Goodridge constructed, under my supervision, a transmitter, such as shown in my caveat of February 14, 1876. Not having any of my universal receivers there, except the wooden sounding box receiver, we did not have an opportunity to test it at that time. Early in July, I think before the 10th, I was sent to New York, or rather I went to New York at the request of Dr. White, who had a large pecuniary interest in my telegraphic inventions, for the purpose of equipping a wire between New York and Philadelphia with my multiple telegraph apparatus. A few days after my arrival in New York I was taken sick with what was supposed to be sunstroke. I was sick and unable to attend to my business, but very little of the time until late in the fall, at which time we completed our demonstration between New York and Philadelphia. After this, at the request of Mr. Orton, then president of the Western Union Telegraph Company, and Dr. White, I proceeded to demonstrate the capacity of my system for working longer lines, and to that end went to Buffalo, spending some time there; after which I went to Chicago. All of the winter of 1876–7 I spent in this work, and during the spring and summer of 1877 was engaged in equipping different wires of the Western Union Telegraph Company, and demonstrating its capacity to work in connection

with the ordinary Morse system. I was so engaged up to the fall of 1877.

Int. 60. Will you explain why your sounding box receiver was not adapted for a test of your caveat telephone transmitter?

Ans. It is a peculiarity of that receiver and receivers of that class that while they will reproduce a tone or sound transmitted with a considerable degree of force (as by the use of a strong battery) with much greater loudness and clearness than by a receiver such as the concave diaphragm or resonant box receiver, they are not so good for receiving tones or sounds transmitted with a weak force, such as if transmitted by an ordinary speaking telephone.

Adjourned to April 4, 1879, at 10.30 A. M.

NEW YORK, April 4, 1879, 10.30 A. M.

CROSS-EXAMINATION BY CHAUNCEY SMITH, ESQ., OF COUNSEL FOR COMPLAINANTS:

Cross-Int. 61. In your answer to the fifth interrogatory you say that the American Company's manufacture of telephones is conducted under license from owners of your patents put in evidence in this case, so far as such patents are applicable to telephones, who is the owner of the patents referred to?

Ans. The Harmonic Telegraph Company.

Cross-Int. 62. When was that license given?

Ans. At the date of the organization of the American Speaking Telephone Company, about the 6th December, 1877.

Cross-Int. 63. Was that license in writing?

Ans. I called it a license. We made a written contract, as I recollect it, the effect of which was to convey to the American Speaking Telephone Company the privilege of using anything that occurred in any of my patents relating to speaking telephones. I do not know just what the document would be termed in law. I will further explain that there were three parties to the agreement, the other party being the Gold and Stock Telegraph Company, who were made the agents of the American Speaking Telephone Company.

Cross-Int. 64. The agents to do what?

Ans. To manufacture speaking telephones and place them upon the market.

 2351

Cross-Int. 65. Did the agreement make any provision in respect as to who should bear the expenses of any litigation which might arise in the course of the business of either company in relation to speaking telephones?

Ans. It provided that such expenses should be advanced by the Gold and Stock Telegraph Company and reimbursed to them out of the proceeds of the telephone business.

Cross-Int. 66. Did the contract make any provision that the Gold and Stock Company should be the owners of any of the capital stock of the American Speaking Telephone Company; if so, what proportion?

Ans. Yes, two-thirds.

Cross-Int. 67. Who was to own the other third?

Ans. The Harmonic Telegraph Company.

Cross-Int. 68. When was the Harmonic Telegraph Company organized?

Ans. May 26, 1876.

Cross-Int. 69. Between the time when the Harmonic Telegraph Company was organized and the time of the organization of the American Speaking Telephone Company, were you a stockholder and officer in the former company?

Ans. I was.

Cross-Int. 70. Can you state when the negotiations commenced between the Harmonic Telegraph Company and the Gold and Stock Telegraph Company, or any parties interested therein, which resulted in the contract to which you have referred?

Ans. I cannot state definitely at present. It was some time during the fall preceding the organization of the American Speaking Telephone Company.

Cross-Int. 71. Did you personally take part in the negotiations?

Ans. I did. I mean by that I was present at a number of interviews during the pendency of the negotiations.

Cross-Int. 72. Do you remember who else was present, either as representing your own company or the Gold and Stock Company?

Ans. At some of these interviews Dr. Samuel S. White, of Philadelphia, and E. W. Andrews, of New York, who were representatives of the Harmonic Telegraph Company; Mr. William Orton, Mr. George Walker, Dr. Norvin Green, Mr. Banker—I have forgotten his initials—Mr. Tracy R. Edson and Mr. George B. Prescott were present. These are all that I call to mind at this moment, and I do not know that they were all present at any one time.

Cross-Int. 73. Mr. Orton and the persons named after him were there on behalf of the Gold and Stock Telegraph Company, were they not?

Ans. That was my understanding.

Cross-Int. 74. Did you understand that any of them were officers of the company, and if so, what offices did they hold?

Ans. I understood that Mr. Orton was president of the Gold and Stock, Messrs. Walker and Prescott vice-presidents; and the other gentlemen named, I think, were members of the executive committee or directors in the same company.

Cross-Int. 75. Where did the interviews take place at which you were present?

Ans. Generally in the Western Union Building, New York, and I think, most frequently, in Mr. Walker's room.

Cross-Int. 76. Mr. Orton was president of the Western Union, was he not, at that time?

Ans. He was.

Cross-Int. 77. Did you understand that the other gentlemen representing the Gold and Stock Telegraph Company were any or all of them officers in the Western Union Telegraph Company?

Ans. Some of them were, but not all.

Cross-Int. 78. Will you name those that were officers and the offices they held?

Ans. Norvin Green was vice-president of the Western Union; Mr. Banker, I think, was a director, but I am not sure that he was at that time; Mr. George B. Prescott was an electrician. The other gentlemen had no connection with the company, to my knowledge.

Cross-Int. 79. What business was the Harmonic Telegraph Company organized to carry on?

Ans. It was organized to exploit, in whatever way seemed most feasible, my inventions and patents relating to the general subject of telephony. I mean by telephony any invention in which the transmission, electrically, of musical tones or sounds was employed.

Cross-Int. 80. What was the significance of the word "harmonic," in the name of that company?

Ans. As the question is put, I don't quite understand it.

Cross-Int. 81. Do you know whether or not the term was used as indicating the nature of the business which was to be transacted or the inventions which it was to exploit?

Ans. I think the name was suggested by the fact that in some

of my inventions and patents, which were to be owned by the company, a means was shown for transmitting harmony.

Cross-Int. 82. Will you state what the Harmonic Company did from the time of its formation down to the time of the contract which you have referred to, in exploiting your inventions?

Ans. In answer to question 59, in my direct examination, I have given a general account of my own work from the 15th of January, 1876, till the fall of 1877. I was then in the employ and under the direction of the Harmonic Telegraph Company. Others besides myself were also employed by the same company—at least one during all of this time—others during a portion of the time.

Cross-Int. 83. Several patents of yours have been put in evidence which have reference to telegraphing by means of sounds, broken up into long and short periods, corresponding to the dots and dashes of the Morse alphabet; do these inventions and the instruments described in the patents, come properly within the meaning of the term telephones, or telephonic instruments or inventions, as the terms have been generally understood for a number of years past.

Ans. I have always understood that any instrument or apparatus capable of transmitting sound to a distance was properly called by the name telephone, whether this instrument be electrical or electro-mechanical or mechanical only; and I will add, that my first inventions relating to the transmissions of musical tones electrically I called telephones.

Cross-Int. 84. In the various transmitting instruments described in your several patents, and in the several transmitting instruments which have been produced here in evidence, in which a vibrating reed is employed, do such reeds form a part of an electric circuit which is broken by the vibration of the reeds?

Ans. All the patents showing vibrating reeds, and the several instruments put in evidence having vibrating reeds, such reeds do, in one sense, break an electric circuit, and, in the same sense, form a part of an electric circuit.

Cross-Int. 85. What do you mean by saying "in one sense"—do not the reeds, in fact, form part of an electric circuit through which a current passes a portion of the time?

Ans. In some cases the vibrating reed serves simply to divert a portion of the electric current (produced by a given number of cells of galvanic battery) from the main line, through a short or shunt circuit in which the vibrating reed is placed. In this case the reed

does not open the main circuit, neither does it divert the whole of the battery from it, but it does make and break the before mentioned short or shunt circuit.

Cross-Int. 86. I did not ask you anything about the main circuit; I want to know if, in those instruments, the reed itself forms a part of the circuit through which at times a current flows?

Ans. It does.

Cross-Int. 87. Is not that portion of the circuit of which the reed forms a part broken by the vibration of the reed?

Ans. It is.

Cross-Int. 88. In its normal state, when the reed is at rest, and no current flowing through the circuit of which it forms a part, the circuit at those parts connected with the reed or in contact with the reed is closed, is it not?

Ans. It is closed.

Cross-Int. 89. Now, starting with that condition of things, if a current is allowed to pass through a circuit in which the reed is placed, it sets the reed in motion, does it not?

Ans. Not necessarily.

Cross-Int. 90. Is not that what it does in the practical operation of the instruments described in the patents, and in the transmitting instruments referred to, which have been produced in evidence?

Ans. That is the case with, I think, all the instruments produced in evidence, but not in the case in some of the patents put in evidence.

Cross-Int. 91. In which one of the patents showing a vibrating reed forming a portion of a circuit is this not the case when the instrument is used in the manner it is designed to be used?

Adjourned to April 5, 1879, at 10.30 A.M.

NEW YORK, April 5, 1879, 10.30 A.M.

Ans. In my patents, numbered respectively 186,340, dated January 16, 1877; 179,549, dated July 4, 1876; 205,378, dated June 25, 1878, reference is made to a transmitter describing in my patent No. 165,728, granted July 20, 1875. In this transmitter the reed forms a common track for two circuits through a part of their length. One circuit connecting with the reed branches off on the right hand break-point is represented in the figure, passing directly to the

other pole of the battery, without passing through any electro-magnet; the other circuit connects with the reed, passing off at the left hand break-point through the magnets of the instruments, completing a circuit through a local battery. When used in the systems shown in the above-named patents, the closing of one circuit would not vibrate the reed, while, closing the other with the battery, it would vibrate the reed.

Cross-Int. 92. Then, if I understand you, whenever the reed, being in a state of rest, is set in motion, it is set in motion by a current which passes through it?

Ans. It is.

Cross-Int. 93. And in all these instruments having vibrating reeds, the movement of the reed breaks the circuit of which it forms a part, and interrupts the flow of the current. Is that so?

Ans. That is so.

Cross-Int. 94. Now, what effect does this temporary current produce in the receiving instrument, whatever it may be? I mean, of course, the receiving instruments which you have produced in evidence as being made in 1874 and 1875.

Ans. I understand you to mean, by temporary current, that current which flows through the reed and its contact point at the moment they are closed. The effect of closing this circuit, when the transmitter is connected, as shown in the several patents referred to in my ninety-first answer, is to divert that portion of the battery which is included in this temporary circuit from the main line in which the receiver is placed, or a large portion of it, thus causing, at each vibration of the reed, an electrical impulse or wave to pass over the line, which acts upon the receiver in the same manner that a similar impulse obtained by any other mode would.

Cross-Int. 95. Now, do not the vibrations of the reed of the transmitting instruments, if they are sufficiently rapid, produce, in addition to the electrical waves you have spoken of, sounds or sound waves in the atmosphere, which are given off into the space surrounding the vibrating reed?

Ans. They do.

Cross-Int. 96. I find in the caveat which has been put into evidence, filed by you in the Patent Office February 14, 1876, these statements, following a description of the apparatus shown in the drawings: "Owing to this construction, the resistance varies constantly in response to the vibrations of the diaphragm, which, although irregular, not only in their amplitude but

in rapidity, are nevertheless transmitted, and can, consequently, be transmitted through a single rod, which could not be done with a positive make and break of the circuit employed, or where contact points are used. I contemplate, however, the use of a series of diaphragms in a common vocalizing chamber, each diaphragm carrying an independent rod, and responding to a vibration of different rapidity and intensity, in which case contact points mounted on other diaphragms may be employed." I find no representation in the drawing of the apparatus referred to in the last sentence of the quotation, if I understand them, and I am unable, from the description, to make out what this apparatus was to be. Will you please explain it, stating what things you intended to use, and how they were to be arranged, and what their operation would be?

Ans. The apparatus proposed in the sentence referring to a series of diaphragms, while it was not clearly defined in all its details in my mind at that time, I had this general idea. I have stated in the preceding sentence to the one under discussion in my caveat, in substance, that articulate sounds could not be transmitted successfully where a positive make and break in the circuit was employed. In making this statement I had in mind one form of the Reis telephone with which I was familiar, which had a fixed point so adjusted in relation to a diaphragm that when the diaphragm was thrown into vibration by the voice, or other sound, it would make and break contact with this fixed point; and if an electric current were passing through it, it would be interrupted. The idea I had in mind where I speak of the series of diaphragms, each carry an independent rod, &c., was not to have the rods or points to vibrate against another fixed point, but to have such points mounted in some manner that they would yield, as, for instance, on another diaphragm, or somewhat after the manner shown in my patent No. 194,671, granted August 28, 1877. This patent shows a diaphragm having a light lever hinge at one end, while the other rests upon the center of the diaphragm, which has glued upon it a small piece of platinum, making the electrical connection with the binding post. The operation of such an apparatus as last described, in contrast with the one described having a point with a fixed relation to the diaphragm, is very different. In the latter arrangement, when the diaphragm is thrown into vibration, it does not necessarily produce an actual break in the circuit. If the vibration is too powerful, it will; otherwise, it simply has the effect of varying the resistance, and the variation of resistance is proportional, within certain limits, to the amplitude

of vibration of the diaphragm. The idea of using a series of diaphragms, differently stretched or tuned, I supposed at that time would give the instrument a greater range—a theory which has since proved to be false. Although the instrument would operate if so constructed, but not so well as with a single point.

Cross-Int. 97. Was the fact that the resistance to a current of electricity passing through two points in contact would vary with the pressure between those points and within certain limits in proportion to the pressure a well-known fact in electrical science at the time your caveat was filed?

Ans. It was well known to me as far back as 1867, and, I believe, it was old in the art at that time.

Cross-Int. 98. Part of the exhibit embracing your caveat, Defendant's Exhibit Gray's Caveat, is a notice to caveator, dated February 19, 1876, containing the following: "You are hereby notified that application has been made to this office for letters patent for telephonic telegraph, etc., with which the invention described in your caveat, filed on the fourteenth day of February, 1876, apparently interferes," etc. The notice concludes as follows: "If you would avail yourself of your caveat, it will be necessary for you to file a complete application within three months from date; three days additional, however, being allowed for the transmission of this notice to your place of residence." This notice is addressed: "Elisha Gray, care of W. D. Baldwin, present." Did you, personally, see this notice, or know that it was sent at the time, or about the time?

Ans. I am quite sure I saw it. I certainly knew it was sent within a few days of the time.

Cross-Int. 99. Did you know or understand whose application it was which is referred to in the notice as interfering with the invention described in your caveat?

Ans. At the time I received the notice I did not know.

Cross-Int. 100. When did you first learn?

Ans. I do not know that I ever learned except from what I inferred from the official record in the case.

Cross-Int. 101. What did you infer from the official records of the case, and when did you make that inference?

Ans. I supposed it to be Professor Bell's application from two or three facts. One was the correspondence with Pollok and Bailey, who were Professor Bell's attorneys in another case or cases, relating to the transmission of musical sounds. Another thing, which

led me to suppose such was the case, was the fact, that a few days after I was notified to complete my application, I received a letter through my attorney, Mr. Baldwin, notifying me that the notice to complete, previously sent me, was withdrawn. Shortly after this a patent was issued to Professor Bell which helped to confirm me in the idea I before had, that he was the interfering party. I wish to add that, as to the official correspondence referred to, I do not now recall at which time I first saw it; whether it was before the issue of Professor Bell's patent of March 7, 1876, or after.

Cross-Int. 102. Had there not been, for some considerable time, one or more interferences in the office between yourself and Professor Bell upon inventions relating to musical telephones, or the multiple transmission of messages by means of sounds representing the Morse characters?

Ans. There was an interference between myself and Professor Bell on applications filed by me on the 23d of February, 1875, and by Professor Bell on the 25th of February, 1875. I think, perhaps, two previous applications of mine were also involved to some extent.

Cross-Int. 103. When did you first see the specification of Mr. Bell's patent of March 7, 1876, to which, as I understand you, you have just referred?

Ans. I think it was during the same month of the issue of the patent. My recollection is that Mr. Baldwin sent me a copy to Philadelphia, where I was then stopping.

Cross-Int. 104. You referred, in your direct examination (in your fifty-first answer), to a lecture of Professor Bell's, a printed copy of which was sent to you by some one about the time of Professor Bell's exhibition at the Centennial; will you look at the pamphlet I now hand you, and state whether or not it is the same lecture as that of which you received a printed copy?

Ans. It is the same, to the best of my recollection.

Complainant' counsel offer the pamphlet in evidence and the same is marked "Complainants' Exhibit 9, W. C. W., Ex'r."

Defendant's counsel objects to the use by the complainants, in evidence, of the statements of Professor Bell made in the said pamphlet.

Cross-Int. 105. In your answer to the fifty-third direct interroga-

tory you gave a description of certain apparatus of Professor Bell's which you saw at the Centennial. Who was present at the time you saw that apparatus?

Ans. There were a large number of people present, and of those I call to mind at this moment I will name Professor Bell, the Emperor of Brazil, Sir William Thomson, Professor G. F. Barker, Professor James C. Watson, Professor Hillgard, Rudolph Koenig. Those are all I think of just now.

Cross-Int. 106. Did you, at that time, see the apparatus tried which you described in your direct examination?

Ans. I did.

Cross-Int. 107. What did you see done with it?

Ans. I saw, at the receiving end, several persons holding the receiving instrument to their ears. At the transmitting end, I saw a man talking into the instrument, that I have described as the transmitter.

Cross-Int. 108. Did you yourself try the receiving instrument to your ear?

Ans. I did. The Emperor had just been using the receiving instrument; as he took it down from his ear and started away to the transmitting end, he said: "To be or not to be." From this I took the clue as to what was being recited at the transmitting end. I listened intently for some moments, hearing a very faint, ghostly, ringing sort of a sound; but, finally, I thought I caught the words "Aye, there's the rub." I turned to the audience repeating these words, and they cheered.

Cross-Int. 109. Was that the first time you had heard articulate speech transmitted over an electric circuit?

Ans. It was the nearest approximation to articulate speech that I had ever heard.

Cross-Int. 110. It was the first time, was it not, that you had listened at a speaking telephone apparatus for the purpose of hearing what it would do?

Ans. I made some experiments about the same time in the Exposition Building with a transmitter that I have referred to in my direct testimony; but I am unable, at this time, to state whether those experiments were conducted before or after Professor Bell's exhibition. My impression is, it was after. If so, the results I obtained at Professor Bell's exhibition were the first approximating articulate speech transmitted by the human voice.

Cross-Int. 111. In your experiments with your own transmitter in the Exposition Building, what did you use for a receiver?

Ans. I used the wooden sounding-box receiver, as that was the only thing I had there.

Cross-Int. 112. Was that transmitter made in Philadelphia?

Ans. It was.

Cross-Int. 113. Was the construction of that transmitter the first attempt you had made to construct the apparatus specifically described and represented in the drawings of your caveat?

Ans. I believe it was. Of this I am not quite certain.

Cross-Int. 114. You described in your direct examination a transmitting instrument exhibited by Professor Bell on the occasion referred to; did you see a different transmitting instrument among the apparatus exhibited by Professor Bell?

Ans. I have no recollection of having seen any other than the one described.

Cross-Int. 115. What apparatus did you exhibit to the Judges on that day?

Ans. I exhibited the musical telephone adapted to the transmission of tunes, consisting of a key-board transmitter and a variety of receivers, among which was a wooden sounding box receiver, another having a series of sounding boxes connected by one bar, and the revolving drum receiver. In addition to this I exhibited my harmonic telegraph system, substantially as described in my patent No. 186,340, granted January 16, 1877. I also exhibited a receiver shown in my patent 166,094, granted 27th July, 1875. With this receiver I exhibited the method of making the tone single operate an ordinary Morse sounder. The other telegraphic receivers were substantially like those described in my patent No. 175,971, granted April 11, 1876.

Cross-Int. 116. Was the wooden box receiver which you had there, the one, or like the one, which has been put in evidence, marked "Gray's Wooden Sounding Box Magnet Receiver?"

Ans. It was substantially like it. I think the box was larger somewhat, and had S-shaped openings in the top instead of the side, as in the exhibit.

Cross-Int. 117. Did you see the reports of the Judges when they were made upon the apparatus exhibited by you, and also upon that exhibited by Professor Bell?

Ans. I saw the report made upon my own apparatus, but not on that of Professor Bell.

 2361

Cross-Int. 118. Did you see this report upon your apparatus before it was printed or afterwards?

Ans. I first saw it when it was sent to me officially by the officers of the exposition.

Cross-Int. 119. When did you first see the printed reports of the Judges issued in volumes, especially the volume containing the report on your own apparatus?

Ans. I have no recollection now of having ever seen it; certainly not to read it.

Cross-Int. 120. Have you ever seen that upon Professor Bell's apparatus?

Ans. I have not.

Cross-Int. 121. Will you look at pages 92 and 93 in George B. Prescott's book entitled, "The Speaking Telephone, Talking Phonograph and other Novelties," and state whether you ever before read what there is on those pages, purporting to be the official report of an instrument exhibited by Mr. Bell, at the Centennial Exhibition, signed by Sir William Thomson and others.

Ans. I think this is the first time I ever read consecutively, either the official report or what purported to be of Sir William Thomson, regarding Professor Bell's exhibit at the Centennial. I have seen statements in the newspapers of a somewhat similar character; and I call to mind particularly an extract from Sir William Thomson's address after he went back to Europe.

Cross-Int. 122. When did you first see such statements and extracts?

Ans. The first that I recollect now was contained in the before mentioned address of Sir William Thomson. This I saw some time in the fall of 1876; I cannot fix the date accurately.

Cross-Int. 123. Will you look at page 21 printed reports and awards, group 25, of the Centennial Exhibition; state whether you ever before saw what is contained in that page, with reference to Professor Bell's Exhibits, either in this book or in any other publication, or any part of it; and, if so, when you first saw it?

Ans. I did not see it in the book above mentioned, and I cannot swear that I ever saw that article in any publication. I have seen newspaper extracts that read in a somewhat similar manner and my recollection is, that I saw something of the kind late in the fall of 1876 or in the winter of 1876–7.

Cross-Int. 124. Did you, about the time you saw Professor Bell's apparatus at the Centennial Exhibition, call on Professor Bell at

substance between the two instruments, that the result might possibly be obtained by mechanical transmission through the wire. I may have said so in the presence of Professor Watson, although I do not now recollect it. I have above said that I did not say that the electrical transmission of articulate speech was impossible. I could not have said it, because I knew not only from my own experiments, but from what I heard on Professor Bell's instrument at the first exhibition, I believed then, and have ever since, that the results I obtained were due to electrical transmission, and not mechanical.

Adjourned to Monday, April 7, at 10.30 A. M.

NEW YORK, April 7, 1879, 10.30 A. M.

Cross-Int. 127A. Will you look at the report of the Judges previously referred to on pages 20 and 21, and on pages 131 and 132, and state whether the articles on those pages, so far as they relate to your inventions, are, either or both of them, the report or reports which were sent to you from the Judges?

Ans. The report, on pages 20 and 21, I should say, was a brief abstract of the full report, found on pages 131 and 132. I believe this latter to be the same as contained in the official report sent to me. I cannot be positive as to exact wording, without reference to that report.

Cross-Int. 128. Will you look at pages 13 and 196, and state if you find to whom the respective articles are attributed as the authors?

Ans. The article first referred to, on pages 20 and 21, is part of the general article entitled "Electrical Apparatus," by Joseph Henry, LL.D. By reference to page 196, I find the following: "The figures annexed to the names of the Judges indicate the reports written by them respectively," referring back to page 131, report No. 4, would be accredited to Sir William Thomson.

Cross-Int. 129. Will you look at page 21 at Professor Henry's general report, and state whether you find the article relating to your invention followed by one relating to the invention of Mr. Bell, forming a part of the same general report?

Ans. I find on page 21 a reference and short description of an invention which the writer claims to be that of Mr. Bell.

Cross-Int. 130. Will you state whether these two articles are embraced under one specific heading or title on page 20, and if so, what that title is?

Ans. I find on page 20 a heading which reads, "The Electric Telephone and Multiple Telegraph," and I find the two articles above referred to embraced under that heading.

Cross-Int. 131. Will you look at pages 130 and 131, same volume, and state whether you find there a report relating to Professor Bell's exhibit at the Centennial, and if so, to whom the authorship of that is attributed?

Ans. I find on pages 130 and 131 of the volume referred to a report of Professor Bell's exhibit at the Centennial. By reference to page196 I find this report accredited to Sir William Thompson.

Cross-Int. 132. Will you look and see if that report is the same as that of the article in Prescott's book, pages 92 and 93, to which your attention has already been called.

Ans. I find a portion of that report quoted in Prescott's book; and beginning about the middle of the report it is quoted word for word, for a number of sentences, the balance being simply a brief abstract.

(Complainants offer in evidence the article on pages 20 and 21 of Professor Henry's report, under the title of "The Electric Telephone and Multiple Telegraph," marked "Complainants' Exhibit No. 10, W. C. W., Ex'r."

Also the article No. 3, same volume, on pages 130 and 131, under the title "Alexander Graham Bell, Salem, Mass., U. S.," marked "Complainants' Exhibit No. 11, W. C. W., Ex'r."

Also the article in same volume, pages 131 and 132, No. 4, under the head "Elisha Gray and Samuel Stockton White, Chicago Illinois, U. S., marked "Complainants' Exhibit 12, W. C. W., Ex'r.")

(The use in evidence of the three printed articles just above mentioned and offered in evidence by the complainants, is objected to.)

Cross-Int 133. In the fifty-ninth direct interrogatory you were asked to state how you were occupied in the year 1876, and down to October, 1877, etc. State whether or not in addition to what you stated in your answer to that interrogatory as to your occupa-

2366

tion during those years, you delivered a lecture on the 27th of February, 1877, at McCormick's Hall, Chicago, at which you exhibited sundry inventions of your own, and explained their character?

Ans. I did deliver such a lecture, making such exhibitions, in McCormick's Hall, Chicago, on or about the date mentioned.

Cross-Int. 134. State whether or not, in the course of that lecture, you made any reference to Professor Bell and his invention of the speaking telephone.

Ans. I did make reference to Professor Bell, and I explained his invention, as I have heretofore described as his in my direct examination; to aid in which I used diagrams and had a pair of instruments on the stage, not in circuit, constructed on the same principle.

Cross-Int 135. When and by whom were those instruments constructed?

Ans. My recollection is, that they were made perhaps a month previous to the lecture, by a workman in the shops of the Western Electric Manufacturing Company, by the name of De Hondt. The instruments were owned by him, and I borrowed them for that occasion.

Cross-Int 136. Will you look at the copy of the "Chicago Tribune" which I now hand you, dated February 20, 1877, and state whether you find in it, under the head of "The Telephone," a report of that lecture, and if so, whether it is substantially a correct report of that lecture, so far as it goes?

Ans. I find in that paper what purports to be a report of a lecture delivered by me at McCormick Hall, but I cannot say that it is a correct report, except in a very general sense. It seems to be a brief synopsis of the impressions made upon the reporter's mind at the time, and it is not in any sense a *verbatim* report, except, perhaps, in the case of a few detached sentences.

(Complainants offer in evidence said report, and it is marked "Complainants' Exhibit No. 13, W. C. W., Ex'r.")

Objected to.

Crosss-Int. 137. Did you before delivering that lecture have any correspondence with Professor Bell in respect to the lecture and to the exhibition of his invention of the speaking telephones?

Ans. I wrote him two letters about that time, I think both of

2367

them before the lecture, and I remember the first one had reference to the exhibition of his invention at that lecture.

Cross-Int. 138. Will you look at the letter I now hand you, and state whether or not it is the first letter which you sent to him?

Ans. It is the first letter.

Cross-Int. 139. Will you read it to the magistrate, to be taken down by him in answer to this question?

Ans. I will. It is as follows:

"CHICAGO, February 21, 1877.

"PROFESSOR A. G. BELL:

"MY DEAR SIR—I gave a lecture in McCormick Hall, this city, Tuesday evening, 27th inst., on the telephone as I have developed it. I also connect with Milwaukee and have tunes and telegraphing done from there. I should like to explain and exhibit your method of transmitting vocal sounds as well, but do not feel at liberty to do more without permission from you. I should explain it as your method, and not mine, although the office records show a description of the talking telegraph filed by me the same day yours was filed. The description is substantially the same as yours. I was unfortunate in being an hour or two behind you. There is no evidence that either knew that the other was working in this direction.

"Without our facilities, I can get up an apparatus on a day's notice that will answer. I have a copy of your last patent, please telegraph at my expense, on receipt of this, yes or no, and I will act accordingly.

"Yours truly,
"ELISHA GRAY,
"220 Kinsey Street,
"Chicago.

"I send this care Mr. Hayes, as I do not know your address. I received a line from you through Mr. Baldwin, for which please accept thanks."

Cross-Int. 140. I notice that in this letter you request Mr. Bell to telegraph you in reply; state whether or not he did so?

Ans. He did.

Cross-Int. 141. Have you got his reply; if so, will you please read it?

Ans. It is as follows:

"BOSTON, Feb. 24, 1877.

"ELISHA GRAY,

"Western Electric Mfg. Co.:

"If you refute in your lecture, and in the "Chicago Tribune," the libel upon me published in that paper February sixteenth, I shall have no objection. Please answer.

"A. GRAHAM BELL."

Cross-Int. 142. Did you reply to that telegram?

Ans. I did.

Cross-Int. 143. Will you look at the letter I now hand you and state whether it is the one you sent in reply to the despatch, and if so, read it to the magistrate as a part of your answer?

Ans. It is. It is as follows:

"CHICAGO, Feb. 24, 1877.

"PROFESSOR A. G. BELL.

"SIR—Your telegram received. In answer I would say, first, that I do not know what article you refer to, but will see the paper of that date. I have seen one or two articles lately that venture to assume that you are not the only man in the world who had contributed to the development of the telephone. If such assertions are 'libels,' then you have been libeled, so far as I know the 'libels' are mostly on the other side; if assertions of originality, etc., may be so considered. The papers here have been full of articles of late, copied from Boston papers, claiming the whole development of the telephone for you. It would not be strange if some one, knowing the facts, should speak, and in doing so, may have done you an injustice.

"You seem to assume that I am responsible for all the newspaper articles that are not in your favor. I assert here that I have never said a word about you in the public prints, and I have always—even to the degree of offending some of my friends—defended you when I have heard disparaging remarks made about you; and since I made your acquaintance I have taken the ground that we were both independent inventors. Now, if we are going into the refutation business I suggest that it be mutual. So far as I know, there is quite as much needed from your side as from mine. I am always willing to correct any wrong done you, even although I am not responsible. If we undertake to follow up the newspapers we will have our hands full. I shall not show your apparatus, as I do

not want any conditions imposed until I know what I am expected to refute. I do not know but that it is to deny all claim to the invention. Allow me to suggest that your telegram was just a little indiscreet, as it contained an assumption very unjust to me.

"I do not know your address, so I send through Mr. Hayes.

"Yours truly,

"E. GRAY.

"P. S.—You should have sent your despatch collect as I requested it sent."

Cross-Int. 144. In this letter you say, near its commencement, "I do not know what article you refer to, but will see the paper of that date." Did you examine the paper and ascertain what the article was?

Ans. I believe I did.

Cross-Int. 145. Will you look at the date of the copy of the "Chicago Tribune," which I now hand you, of the date of February 16, 1877, and state if you find in it the article which you suppose to be referred to by Professor Bell; and if so, point out to the magistrate and allow him to copy it as part of the answer?

Ans. I find an article in the personal column of the "Chicago Tribune," of the date above referred to, an article that I supposed to be the one referred to by Professor Bell in his telegram. It is as follows:

"Many of the Eastern newspapers are favoring their readers with sketches of Prof. A. M. Bell, 'the inventor of the telephone.' Meanwhile the real inventor of the telephone—Mr. Elisha Gray, of Chicago—minds his own business and apparently concerns himself not at all about the spurious claims of Professor Bell. Persons acquainted with the subject need not be informed that Mr. Gray's claims are incontrovertible. Science long since recognized them. They were established in the columns of the "Tribune" years ago, before Professor Bell was so much as heard of. They are officially approved in the Patent Office at Washington, and they have already brought in large returns in money as well as in reputation to the inventor. Talking by telegraph and other sport of that description Mr. Gray has not paid much attention to as yet, because there is no present indication in it of anything more than sport; but the principles involved in it were discussed by him, and have all been used by him in a practical manner."

Cross-Int. 146. Did you receive from Professor Bell a reply to

your second letter; if so, will you produce it and read it as a part of your answer?

Ans. I did. It is as follows:

"BOSTON UNIVERSITY, March 2, 1877.

"ELISHA GRAY, ESQ., Chicago.

"MY DEAR SIR—I was somewhat hasty, I must confess, in sending my telegram, for of course you are not responsible for all the ill-natured remarks that may appear in the newspaper concerning me.

"I am sorry that my telegram should have prevented you from making the experiments you desired, for it is my sincere desire to oblige you in any way I can. I am glad that you are willing to do me justice, and must thank you for saying a good word for me occasionally. I may say that it has uniformly been my custom to make honorable mention of your name in multiple telegraphy, and to give you the credit of being an independent inventor.

"I have not generally alluded to your name in connection with the invention of the electric 'Telephone,' for we seem to attach different significations to the word. I apply the term only to an apparatus for transmitting the voice (which meaning is strictly in accordance with the derivation of the word), whereas you seem to use the term as expressive of any apparatus for the transmission of musical tones by the electric current.

"I have no knowledge of any apparatus constructed by you for the purpose of transmitting vocal sounds, and I trust that I have not been doing you an injustice. It is my sincere desire to give you all the credit that I feel justly belongs to you.

"I do not know the nature of the application or caveat to which you have referred as having been filed two hours after my application for a patent, excepting that it had something to do with the vibration of a wire in water, and, therefore, conflicting with my patent. My specification had been prepared months before it was filed, and a copy had been taken to England by a friend. I delayed the filing of the American patent until I could hear from him. At last the protest of all those interested in my invention deprecating further delay had their effect, and I filed my application without waiting for a conclusion of negotiations in England. It was certainly a most striking coincidence that our applications should have been filed on the same day.

"I have been kept so busy during the past few days correcting the examination papers of my normal school, that I have been unable to write.

"In haste,

"Yours truly,

"ALEXANDER GRAHAM BELL."

Cross-Int. 147. Will you look now to the letter I hand you, and state whether you sent it to Professor Bell in answer to a letter from him which you have just produced, and if so, will you read it as a part of your answer?

Ans. I did. It is as follows:

CHICAGO, March 5, 1877.

"PROF. BELL:

"MY DEAR SIR—I have just received yours of the 2d inst., and I freely forgive you for any feeling your telegram had aroused. I found the article I suppose you referred to in the personal column of the "Tribune," and am free to say it does you injustice.

"I gave you full credit for the talking feature of the telephone, as you may have seen in the 'Associated Press' dispatch that was sent to all the papers in the country, in my lecture in McCormick Hall, Feb. 27. There were four different papers represented at the lecture, but only one—the 'Tribune'—alluded to my mention of you except the 'Press' dispatch. I described your apparatus at length by diagram.

"Of course, you have had no means of knowing what I have done in the matter of transmitting vocal sounds. When, however, you see the specification, you will see that the fundamental principles are contained therein. I do not, however, claim even the credit of inventing it, as I do not believe a mere description of an idea that has never been reduced to practice, in the strict sense of that phrase, should be dignified with the name invention.

"Yours very truly,

"ELISHA GRAY."

Cross-Int. 148. I find in the certified copies of the file wrapper, contents and drawings of the three applications for patents made by you on the 29th October, 1877, which have been put in evidence,

that letters of the same date were sent by your attorneys to the Commissioner, requesting that a model in each case may be temporarily dispensed with. Why was that request made?

Ans. I had forgotten that such a request had been made, and I am unable to recall now, except that I have a faint recollection that the models were not ready at the time of the filing of the applications.

Cross-Int. 149. Do you mean that they were not constructed or completed?

Ans. Yes, sir; I mean that the instruments we wished to file in the office were probably not completed. I do not mean by this that none of them were ever made before, or instruments substantially like them.

Cross-Int. 150. In constructing the instruments represented in your caveat, on which the diaphragms are stretched, what material would judge it best to use in order to secure the best results?

Ans. I should have but very little choice in the selection of material farther than this: To get the best results I would endeavor to prevent exciting vibrations in either the transmitting or receiving diaphragm other than those excited in the air by the utterance of any given word or sound. To prevent this, it is best to use a material that will not too readily take up the vibrations of the diaphragm. I would name as one very good substance vulcanized rubber as being better either than wood or metal; but the difference is not sufficient to destroy practically the working qualities of the instrument.

Cross-Int. 151. Will you look at Mr. Prescott's book which has been previously referred to by you? State whether you wrote that part of it commencing on page 183 with the words: "In the following pages," and extending to the passage on page 205, closing with the words, "by means of electricity," or any part of it?

Ans. So far as I can judge, without actual comparison, I should say that this was copied from some of my writings.

Cross-Int. 152. When and where was it first published?

Ans. I think the first publication of this particular article appeared in this book—Prescott's.

Cross-Int. 153. When was it written?

Ans. To the best of my recollection, part of it was written some time prior to February 14, 1876. Part of it was not written till the winter or spring of 1877.

Cross-Int. 154. What part of it was written prior to February 14, 1876, and when was such part written?

Ans. The part beginning on page 202, the part entitled Gray's Specification, February 14, 1876. My answer assumes that this is an exact copy of my caveat, but I have not compared the two to see that it is perfectly accurate. It was written, I think, a few days before the date above mentioned, but I cannot definitely fix the time at this moment.

Cross-Int. 155. Will you look at the pamphlet I now hand you, entitled "Journal of the American Electrical Society," published in 1875, Vol. I., No. 1, and state whether or not you wrote the article commencing on page 3 and extending to page 15; and if so, when you wrote it?

Ans. I wrote the article substantially as it appears here, about the time it purports to have been delivered, March 17, 1875. I afterward revised it for publication some time prior to the issue of the journal; to the best of my recollection it was the following fall.

Cross-Int. 156. State, if you remember, whether the second and third numbers of that journal contained articles under your name, which were written by you?

Ans. I remember having written two other articles which appeared in subsequent issues of the same journal.

Adjourned to Tuesday, April 8, at 10.30 A. M.

NEW YORK, April 8, 1879, 10.30 A. M.

The witness, ELISHA GRAY, continues his answer to one hundred and fifty-sixth cross-question:

Since yesterday I have looked at the articles referred to in Nos. 2 and 3 of the said journal, being articles bearing my name, and identify them as articles of my composition.

DIRECT EXAMINATION RESUMED:

Int. 157. In your answer to the eighty-third cross, you say, "I have always understood that any instrument or apparatus capable of transmitting sound to a distance was properly called by the name

telephone." Do you include here under the term "sound," musical or other inarticulate tones, as well as articulate speech?

Ans. I do.

Int. 158. Has the word "telephone" been commonly used among scientific men, in this broad sense, for a time beginning previously to the invention in controversy in this case, and will you give such illustrations of that fact as occur to you?

Ans. It has. And as one illustration, I call to mind a description of what is called the Reis telephone, which will be found in a little work on electricity, by Ferguson, at pages 257 and 258. A reproduction of the cut of this apparatus, substantially as described in the above book, was published some years since, prior to 1874, in the "Manufacturer and Builder." It was also published in "The Telegrapher," at an early date.

Int. 159. Will you look at the application of Mr. Bell, which is referred to in the first one of the patents in suit in this case as a pending application of his, dated February 25, 1875 (a copy of which is in evidence, marked "Defendant's Exhibit A,") and state to what sort of an apparatus you there find him applying the word "telephone?"

Ans. I understand the apparatus referred to by Professor Bell, in the application named, to be such an one as was to be found among the philosophical apparatus of almost any first-class college, and it was a modification of the Reis telephone receiver, and was commonly called Wertheim's apparatus. It consisted of an iron rod from two to three feet long, perhaps a quarter of an inch in diameter, and when used was passed into an ordinary helix. When in operation it was placed in circuit with some vibrating circuit-breaker, as a transmitter, usually vibrating at a very slow rate, and is used to demonstrate the general fact that a bar of iron elongated under magnetization, and also produced a noise at the moment of magnetization or demagnetization. Professor Bell, in his application of February 25, 1875, proposed to use it as a receiver, in connection with the transmitter, which, in general, may be described as an ordinary vibrating electrotome or reed.

Int. 160. Is the apparatus described in this application of February 25, 1875, an apparatus for sending telegraphic signals over a single wire, an intermittent current being produced by a vibratory make and break?

Ans. It is an apparatus designed to transmit telegraphic signals,

and an intermittent current is produced by an actual make and break of the circuit by the vibrator of the transmitter.

Int. 161. You have spoken on your cross-examination of a multiple telegraph which was exhibited at the Centennial in 1876 by Mr. Bell; please describe it?

Ans. As I remember the apparatus, the transmitting portion of it was very similar to the transmitter shown in Professor Bell's application of February 25, 1875. The receiver was substantially the same as shown in that application, with the addition of an arrangement for operating a local circuit, the whole instrument being substantially as shown on page 59 of Prescott's book on the speaking telephone and phonograph. There were two transmitters and two receivers connected in circuit on the same table. I do not know how the circuits were connected with the instruments in detail, and neither can I swear that the instruments were exact reproductions of the cuts I have referred to.

Int. 162. By consent of the counsel for the complainants, I will ask you if you gave an exhibition of the use of your key-board musical transmitter with the concave metallic diaphragm receiver, or with the resonant box magnet receiver, at your dwelling house, in or near Chicago, before going to Europe, in Augnst, 1875; if so, state what apparatus was used, by whom, how, with what results, and what number of persons were present.

Ans. I did. The apparatus I used on that occasion was the two-octave multiple transmitter, now in evidence, the concave metallic diaphragm magnet receiver, a duplicate of which is now in evidence, and the violin animal tissue receiver, now in evidence. The transmitter was placed in the dining-room of the house, and the receivers were placed in the parlor, having the doors closed between. A wire connected the transmitter with the receiver, forming a closed circuit, in which was included a battery, the connections being the same as have been heretofore described. A number of tunes were transmitted from the transmitter to the receiver, and most of the time my wife did the playing while I presided at the receiving end. The results were entirely satisfactory, so that all in the room could hear the tunes that were received, and there were from thirty to fifty persons present. This was the evening before I left home to go to Europe.

Int. 163. Do you know whether any model was filed at Patent

Office with the application for Mr. Bell's patent of March 7, 1876, in suit?

Ans. I don't know.

ELISHA GRAY.

Attest: W. C. WITTER, Examiner.

(Counsel for defendant puts in evidence a certified copy of the correspondence found in file, in the matter of the letters patent granted Alexander G. Bell, March 7, 1876, No. 174,465, for telegraphy; and the same is marked "Exhibit Bell and Patent Office Correspondence, W. C. W., Ex'r.")

The counsel for defendant admits that in an exhibition given by Mr. Elisha Gray, in the City of New York, April 2, 1877, Mr. Gray said substantially, as is reported in the "New York Tribune" of the following day, thus:

"After the first part of the programme had been executed, Mr. Elisha Gray came forward and addressed the audience. He was aware that great confusion existed in the popular mind as to what this telephone could perform; in particular it had been confounded with the speaking telephone invented by Professor A. Graham Bell, of Boston. Prof. Bell, Mr. Gray said, was present in the audience.

(Adjourned.)

(No. 54 c.) Defendants' Exhibit, "Deposition of Elisha Gray (recalled)."

(Introduced by defendants in this Court, from printed record, Bell Telephone Company *et al.* Peter A. Dowd, pp. 279–285.)

J. A. W., Sp. Ex'r.

(Introduced in Record, p. 12.)

DIRECT EXAMINATION BY CAUSTEN BROWNE, ESQ., OF COUNSEL FOR DEFENDANT.

NEW YORK, May 7, 1879.
10 A. M.

Int. 1. It appears from the testimony of Mr. Goodrich that there were made for you in Chicago, in 1874, before you went abroad, two resonant box magnet receivers, like the exhibit of that name, each made of tinned iron and that one of these was sent to Washington as a model accompanying your application for your magnet receiver patent, No. 166,095, dated July 27, 1875. Did you take this resonant box magnet receiver yourself to Washington?

Ans. I did.

Int. 2. Did you personally know that it was deposited in the Patent Office as the model making part of your application for your magnet receiver patent above mentioned?

Ans. I know that it was sent there for that purpose by Mr. Hayes, who was at that time my patent attorney. I will add that Mr. Hayes was in Washington with me at that time, and that the drawings of the magnet and the resonant box were made at Washington, and when completed I compared them with the models.

Int 3. Do you remember seeing the model on the files of the Patent Office at any time after your application was filed or your patent granted?

Ans. I do remember having seen it on several occasions, both in the case in the model room, and in the room of the examiner.

Int. 4. Where in Washington were the drawings made to which you referred just now?

Ans. They were made in the office of Hill & Ellsworth, patent solicitors, to the best of my recollection.

CROSS-EXAMINATION BY J. J. STORROW, ESQ., OF COUNSEL FOR COMPLAINANTS.

Cross-Int. 5. What was the date of the occasions referred to in the third answer?

Ans. I cannot give you the exact dates. I was a frequent visitor at Washington, and often had occasion to look through the model cases, and saw these incidentally. Sometimes I was showing my friends through the office and called particular attention to the models as representing my inventions.

Cross-Int. 6. State as nearly as you can when you recollect having seen in the model room of the Patent Office, in connection with or as part of the model for patent 166,095, a tin box like that of the exhibit referred to in the first question of to-day's deposition?

Ans. To the best of my recollection, the first time I saw it was not a great while after the issue of the patent in which it is represented.

Cross-Int. 7. How soon after?

Ans. I cannot tell how soon it was, but during the first few months following the issue of the patent; it may have been one and it may have been six.

Cross-Int. 8. Are you sure you saw it within six months of the issue of that patent?

Ans. I am sure I saw it, and I believe it was within six months.

Cross-Int. 9. Was it within five months of the issue of that patent?

Ans. I don't know.

Cross-Int. 10. Who was with you on the occasion when you say you saw it?

Ans. I cannot, without refreshing my recollection, state who was with me, as the occasions of my visits were so frequent that I only recollect at this moment the fact that on some of the occasions I had friends with me, but I cannot tell whether there was any one with me the first time I saw it or not.

Cross-Int. 11. When do you think you saw it the second time in the model room?

Ans. I cannot fix the dates exactly, but the times that I saw it occurred between the date of the issue of the patent, July 27, 1875, and about the same date, 1877. I saw one portion of it, namely, the magnet portion, within the last six months. To my best recollection, about mid-winter, 1878–9.

Cross-Int. 12. All my questions as to what you saw in the Patent Office at Washington have had reference to a tin box like that now attached to the exhibit and not to the magnet portion of the receiver. If you have answered the questions upon any different understanding, please say so, and correct your answers, if need be.

Ans. All of my answers, with the exception of so much of the last answer as especially refers to a part, referred to the model as a whole, consisting of the magnet, mounted upon a base, and the tin box.

Cross-Int. 13. Can you fix the occasion when you think you saw in the model room such a tin box as part of the model of the Patent 166,095 any more definitely or any differently from what you have done in your eleventh answer; if you have any recollection' different or more precise than that stated in your eleventh answer, please to give it?

Ans. I cannot fix the dates more definitely at this moment. I think I could do so, however, if I had time to refer to data that would fix the occasions, which I have not with me.

Cross-Int. 14. When did you first go to that model room for the purpose of finding or looking at such tin box?

Ans. I do not recollect at going at any time for the specific purpose of looking for the tin box. The times that I saw it were, as I stated before, when I was looking through the models generally.

Cross-Int. 15. What was the date of the occasion when you think you saw in the Examiner's room, as part of your model 166,095, a tin box like that now tied to the exhibit?

Ans. I cannot fix the date more nearly than I have. The most of the time I saw it was in the model case up-stairs.

Cross-Int. 16. Give me your best recollection as to when you saw such a box, as part of that model, in the Examiner's room.

Ans. To the best of my recollection it was during the latter part of the time between the dates of the issue of the patent and about July, 1877, as mentioned in my eleventh answer.

Cross-Int. 17. What occasion did you have for it in the Examiner's room during that period?

Ans. I had no occasion for it. I merely saw it incidentally when I called on the Examiner, as I frequently did.

Cross-Int. 18. Did you on any of those occasions have any conversation with the Examiner about that particular part of the model which consisted of said tin box?

Ans. Yes; on a number of occasions. These conversations were with reference to the patent and its bearing upon other cases.

CROSS-EXAMINATION BY J. J. STORROW, ESQ., OF COUNSEL FOR COMPLAINANTS.

Cross-Int. 5. What was the date of the occasions referred to in the third answer?

Ans. I cannot give you the exact dates. I was a frequent visitor at Washington, and often had occasion to look through the model cases, and saw these incidentally. Sometimes I was showing my friends through the office and called particular attention to the models as representing my inventions.

Cross-Int. 6. State as nearly as you can when you recollect having seen in the model room of the Patent Office, in connection with or as part of the model for patent 166,095, a tin box like that of the exhibit referred to in the first question of to-day's deposition?

Ans. To the best of my recollection, the first time I saw it was not a great while after the issue of the patent in which it is represented.

Cross-Int. 7. How soon after?

Ans. I cannot tell how soon it was, but during the first few months following the issue of the patent; it may have been one and it may have been six.

Cross-Int. 8. Are you sure you saw it within six months of the issue of that patent?

Ans. I am sure I saw it, and I believe it was within six months.

Cross-Int. 9. Was it within five months of the issue of that patent?

Ans. I don't know.

Cross-Int. 10. Who was with you on the occasion when you say you saw it?

Ans. I cannot, without refreshing my recollection, state who was with me, as the occasions of my visits were so frequent that I only recollect at this moment the fact that on some of the occasions I had friends with me, but I cannot tell whether there was any one with me the first time I saw it or not.

Cross-Int. 11. When do you think you saw it the second time in the model room?

Ans. I cannot fix the dates exactly, but the times that I saw it occurred between the date of the issue of the patent, July 27, 1875, and about the same date, 1877. I saw one portion of it, namely, the magnet portion, within the last six months. To my best recollection, about mid-winter, 1878–9.

Cross-Int. 12. All my questions as to what you saw in the Patent Office at Washington have had reference to a tin box like that now attached to the exhibit and not to the magnet portion of the receiver. If you have answered the questions upon any different understanding, please say so, and correct your answers, if need be.

Ans. All of my answers, with the exception of so much of the last answer as especially refers to a part, referred to the model as a whole, consisting of the magnet, mounted upon a base, and the tin box.

Cross-Int. 13. Can you fix the occasion when you think you saw in the model room such a tin box as part of the model of the Patent 166,095 any more definitely or any differently from what you have done in your eleventh answer; if you have any recollection' different or more precise than that stated in your eleventh answer, please to give it?

Ans. I cannot fix the dates more definitely at this moment. I think I could do so, however, if I had time to refer to data that would fix the occasions, which I have not with me.

Cross-Int. 14. When did you first go to that model room for the purpose of finding or looking at such tin box?

Ans. I do not recollect at going at any time for the specific purpose of looking for the tin box. The times that I saw it were, as I stated before, when I was looking through the models generally.

Cross-Int. 15. What was the date of the occasion when you think you saw in the Examiner's room, as part of your model 166,095, a tin box like that now tied to the exhibit?

Ans. I cannot fix the date more nearly than I have. The most of the time I saw it was in the model case up-stairs.

Cross-Int. 16. Give me your best recollection as to when you saw such a box, as part of that model, in the Examiner's room.

Ans. To the best of my recollection it was during the latter part of the time between the dates of the issue of the patent and about July, 1877, as mentioned in my eleventh answer.

Cross-Int. 17. What occasion did you have for it in the Examiner's room during that period?

Ans. I had no occasion for it. I merely saw it incidentally when I called on the Examiner, as I frequently did.

Cross-Int. 18. Did you on any of those occasions have any conversation with the Examiner about that particular part of the model which consisted of said tin box?

Ans. Yes; on a number of occasions. These conversations were with reference to the patent and its bearing upon other cases.

Cross-Int. 19. Who was the Examiner you conversed with?

Ans. Mr. Wilbur was Examiner during a portion of the time, and Mr. Townsend, since Mr. Wilbur left that department.

Cross-Int. 20. What was the date, as nearly as you recollect, of the first of such conversations with Mr. Wilbur?

Ans. My recollection is that the conversations referring to the before mentioned model were mostly with Mr. Townsend.

Cross-Int. 21. When did you have your first conversation with Mr. Townsend about the model, having at the same time such a tin box, forming part of that model, in the Examiner's room with you?

Ans. I do not recollect when the first conversation took place, but I recollect that the operation of the model, as described in the patent, in some of its bearings was discussed soon after filing the application for reissued patent, granted January 28, 1879, application filed May 7, 1878. I do not think I saw the model at this time or any part of it later than above date till the winter of 1878–9, mentioned in my eleventh answer, my attention then being called for the first time to the fact that the tin box had been mislaid or lost.

Cross-Int. 22. Did you have such a tin box before you in the Examiner's room, as part of that model, upon any of the occasions referred to in your last answer?

Ans. I do not think we had, as there was no occasion for it. The time or times I saw it in the Examiner's room it was on the shelf with the other models. It is always my habit to see everything of that character when I am where they are.

Cross-Int. 22. Was there such a box as part of that model anywhere in the Examiner's room upon the occasions referred to in your twenty-first answer?

Ans. To the best of my recollection, there was such a box in the Examiner's room, and I have a clear recollection of seeing the box carried to the magnet, as shown in Defendant's Exhibit Gray's Resonant Box Magnet Receiver, either in the Examiner's room or in the model case upstairs.

Whole of answer objected to as irresponsive.

Cross-Int. 24. Please to read the last question again and answer it.

Ans. I meant to say in my last answer, that to the best of my recollection there was such a box in the Examiner's room, on some

of the occasions referred to in my twenty-first answer. I think the matter was talked of after the date mentioned, as the time I first discovered that the box was lost, namely, the winter of 1878–9.

Cross-Int. 25. In your twenty-first answer you spoke of some discussions which you say took place in the Examiner's room soon after May 7, 1878. I want to know whether, during those discussions after May 7, 1878, such a hollow tin box, such as is shown in the exhibit, was present in the Examiner's room as part of the model of patent 166,095?

Ans. I have said in my twenty-first answer, in speaking of the discussion which took place after the filing of the reissue application, "I do not think I saw the model at this time, or any part of it," and I here repeat that I do not think that I saw it at that time.

Cross-Int. 26. Am I to understand that you do not know whether such a box existed in the Examiner's room as part of that model, or any of the occasions referred to in the last question?

Ans. I understand your twenty-fifth question to refer only to the discussions which took place in the Examiner's room after the filing of the application for reissue, May 7, 1878, and I mean to say that I do not know whether the model, including the tin box, was in the room at that time or not. I have no recollection of seeing it on that occasion, or any occasion later, so far as the question relates to the tin box.

Cross-Int. 27. Will you now tell me as nearly as you can the date when you did see such a tin box as part of that model in the Examiner's room?

Ans. I cannot fix the dates any nearer than I have in my answer to the sixteenth cross-question.

Cross-Int. 28. The period referred to in that answer, covers two years. Can you fix the occasions as being within the last six months of those two years?

Ans. I cannot with certainty.

Cross-Int. 29. Can you fix them as not being within the first six months of those two years?

Ans. I cannot swear that I did not see it there during the first six months of those two years, but it is my impression, as I before stated that it was later that I saw it in the Examiner's room. By "it" I mean the model, including the box.

Cross-Int. 30. Did you on any occasion when you knew that such a tin box was in the Examiner's room, have any conversation with him on the subject of such a box?

Ans. I have a general recollection that on several occasions the model, including the box, was referred to incidentally, as they naturally would be during the discussions which took place relating to the various applications that I have made from time to time, bearing upon the general subject of telephonic transmission. (I include in that latter phrase what is known as harmonic telegraphy.) And that on some of these occasions the model, including the box, was in the Examiner's room.

Cross-Int. 31. Do you refer in your last answer to any discussions which took place after the period between July, 1875, and July, 1877, mentioned in your twenty-seventh cross-answer?

Ans. I refer to conversations which took place before the date of the filing of the reissue application, May 7, 1878, and to the best of my recollection before July, 1877.

Adjourned to 2.30 P. M.

2.30 P. M.

Cross-Int. 32. What are the "other cases," referred to in your eighteenth cross-answer?

Ans. By "other cases," I referred to my patents, generally, and applications tending, relating to the transmission and reception of musical tones, whether composite or otherwise.

Cross-Int. 33. In those discussions prior to July, 1877, did you refer to or discuss with the Examiner the peculiar functions or mode of operations of the resonator, or box of metal described in your patent 166,095, as distinguished from the rest of the apparatus?

Ans. To the best of my recollection, I did.

Cross-Int. 34. What application was under consideration between you and the Examiner when you had such discussion with him?

Ans. As I recollect it now, this matter was discussed about the time of the issue of the patent No. 166,095, dated July 27, 1875, and of the patent No. 186,340, dated Jan. 16, 1877, and patent No. 175-971, dated April 11, 1876. These are the cases I call particularly to mind.

Cross-Int. 35. In those discussions did you refer to any function or mode of operation or characteristic of such a box other than what is mentioned in the patent No. 166,095?

A. I do not know that all the functions of the resonant box

receiver we discussed are described in the patent. The point at issue was the bearing that this receiver had upon those shown in the above-named patents, numbered respectively 175,971 and 186,340. In the two latter cases receivers are described or referred to, that were adapted to receive a tone or tones of a definite pitch, rejecting all others, whereas the resonant box was used as a common receiver for all tones.

Cross-Int. 36. And was that characteristic or mode of operation of the receiving apparatus of patent 166,095 what you talked about in those discussions?

Ans. It was, so far as the discussions related to the above-mentioned cases.

Cross-Int. 37. Did you, before July, 1877, have any discussions with the Examiner on the subject of such a tin box, except such as related to the cases referred to in your thirty-fifth cross-answer?

Ans. They may have been; but I do not now recollect.

Cross-Int. 38. I notice that your patent No. 166,095 is entitled patent for an "Improvement in Electric Telegraphs for Transmitting Musical Tones," and that the first and second questions in to-day's deposition refer to it as "your Magnet Receiver Patent." When did you first hear it called "Magnet Receiver Patent"?

Ans. I first heard it called magnet receiver in 1874, long before it was patented.

Cross-Int. 39. My question was, when you first heard that patent called your "Magnet Receiver Patent." Please answer when that was?

Ans. To the best of my recollection, about the time it was issued first.

ELISHA GRAY.

Attest:

W. C. WITTER,
Examiner.

The five exhibits next following, marked 54*d*, 54*e*, 54*f*, 54*g*, and 54*h*, are the only exhibits contained between pages 573 and 691 of the printed record, Bell Telephone Company *et al.* vs. Peter A. Dowd, not already inserted in the record in this cause under numbers 41 to 51 inclusive.

J. A. W.,
Special Examiner.

(No. 54d.) **Defendants' Exhibit, "Magnet Receiver Application."**

J. A. W., Sp. Exr.

[Introduced in Record, p. 12.]

DEPARTMENT OF INTERIOR.

UNITED STATES PATENT OFFICE.

To all Persons to Whom these Presents shall Come, Greeting:

This is to certify that the annexed is a true copy from the files of this office of the file wrapper, contents and drawing in the matter of letters patent granted Elisha Gray. Dated July 27th, 1875. No. 166,095. For apparatus for transmitting musical tones by electricity.

In testimony whereof, I, W. H. Doolittle, Acting Commissioner of Patents, have caused the seal of the patent office to be hereunto affixed, this thirty-first day of March, in the year of our Lord one thousand eight hundred and seventy-seven, and of the Independence of the United States the one hundred and first.

[SEAL.]

W. H. DOOLITTLE,
Acting Commissioner.

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1. (ORIGINAL APPLICATION.)

To the Commissioner of Patents:

Your petitioner, ELISHA GRAY, of Chicago, County of Cook, Illinois, prays that letters patent may be granted to him for the invention set forth in the annexed specification; and he hereby appoints Alexander L. Hayes, of Boston, Mass., as his attorney, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent Office connected therewith.

ELISHA GRAY.

To All Whom it may Concern:

Be it known that I, ELISHA GRAY, of Chicago, in the County of Cook, State of Illinois, have invented a new and useful improvement in apparatus for transmitting musical tones by electricity, of which the following is a full, clear and exact description thereof, which will enable others skilled in the art to which the invention appertains to construct and use the same, reference being had to the drawings accompanying and forming part of this specification:

In the drawings, Fig. 1, sheet 1, is a view showing the transmitting apparatus with its connections in plan, and the receiving apparatus in elevation, and Fig. 1, sheet 2, is a view showing the transmitting apparatus in perspective.

This invention is based upon the observed fact well known to electricians, that when *a coil of wire surronnding a bar of iron, or the core of an electro-magnet is traversed* by an electric current, the said bar will be slightly elongated, and if these currents succeed each other with sufficient rapidity, a vibratory motion will be given to said bar, and it will give forth a musical tune.

Erase and insert per Amdt. A, Feby. 3, 1875.

On this principle, an apparatus known as the telephone has been devised, in which the succession of electrical impulses is caused by contacts made by a diaphragm which is thrown into vibration by musical tones produced by the *human voice* or otherwise in near proximity to said diaphragm, but the apparatus does not always operate with certainty, and is liable to become disarranged.

My invention consists in using the secondary currents from an induction apparatus, or the secondary or extra current from a primary coil for exciting *the coil surrounding the bar of iron*, and in causing the succession of said impulses of the induced current by means of a circuit breaker which breaks the circuit with the desired rapidity.

An apparatus which I use is constructed as follows, reference being had to the accompanying drawings:

A is the frame or base of the apparatus at the transmitting end. B is an induction coil of the usual construction, having the usual primary and secondary circuits. C C′, C′ are automatic vibrating electro-tomes of the usual construction, which, when in action, produce musical tones by the vibration of their circuit-breaking springs.

These springs are different in size and adjustment, so that they

vibrate at different rates, and each electro-(to)me therefore affords a tone of a different pitch.

A series of electrotomes may be provided, which will give tones extending through one or more octaves. D D^1 are telegraph keys of the usual construction, which are placed in the primary circuit, the said primary circuit being so divided that a part of the circuit passes through each key and its corresponding electrotome.

The keys are used for making connection with the battery.

When a key is closed, the primary circuit will pass from the battery through one (of) the electrotomes C C^1, by the connection, and the circuit will be automatically broken and closed by the spring of the electrotome corresponding to the key depressed in the manner well known.

The spring will therefore vibrate rapidly, and will produce an *audible tone* of a pitch determined by its rate of vibration, and at the same time a series of induced currents corresponding in number to the number of *audible vibrations* in the tone produced will be induced in the secondary circuit of the induction coil B.

Erase and insert per Amdt. A, Feby. 3, 1875.

The circuit may be of any desired length. At the receiving station in said circuit is placed an *electro-magnet E, or a coil of wire surrounding a bar of iron.* The succession of currents transmitted from the induction coil will cause the vibration of the *core of the electro-magnet.* or *of the bar of iron as before explained,* and it will give forth a musical tone of the same pitch as that produced by the vibrating circuit-closer. *S is a hollow box of metal which is placed upon the poles of the magnet, and intensifies the tone produced by the same.*

It is obvious that by having a series of electrotomes whose vibrating springs give tones of a different pitch, which are properly timed, that the electro-magnet can be made to give forth a succession of tones constituting a melody, and by having a series of circuits and a series of circuit-closers and magnets, *a musical composition of a complicated character can be reproduced at a distance* from where it is played, or the different parts of a musical composition can be played in different places, and be heard in one place simultaneously.

The induced currents being of high tension, can be transmitted through considerable resistance, and is much more effective for magnetizing the magnet than the primary current.

The apparatus can be worked on long circuits with but slight battery power at the transmitting station.

Instead of an automatic electrotome for breaking the circuit, mechanical circuit-closers can be used for producing the succession of currents in the induction coil, and instead of using a secondary coil, the extra or secondary current induced in a primary coil may be used.

This apparatus may be used for various purposes.

For telegraphing letters and signals may be represented by tones of different pitch, which will be readily recognized by an expert operator, and said signals can be made to succeed each other with great rapidity. The Morse alphabet may be transmitted by interruptions of the proper length in a prolonged tone of the same pitch.

Erase and insert per Amdt. A, Feby. 3, 1875.

The apparatus can be used on long land lines or on submarine cables.

What I claim as my invention, and desire to secure by letter patent of the United States, is:

First. The method substantially as described of *producing musical tones* by causing the *vibration of a bar of iron* by transmitting a series *of induced currents through a coil surrounding said bar.*

Second. The combination of an apparatus producing induced secondary currents, with a series of electrotomes or other circuit-breakers, and an electro-magnet arranged in said secondary circuit, substantially as and for the purpose set forth.

In testimony whereof, I have hereunto signed my name this twentieth day of June, A. D. 1874.

Elisha Gray.

Witnesses:

Ewell A. Dick,

Henry R. Elliott.

City of Washington, }
District of Columbia, }

Elisha Gray, the above-named petitioner, being duly sworn, deposes and says that he verily believes himself to be the original and first inventor of the improvements in apparatus for transmitting musical tones by electricity, described and claimed in the foregoing specification; that he does not know and does not believe that the

same was ever before known or used; and that he is a citizen of the United States.

ELISHA GRAY.

Sworn to and subscribed before me this twentieth day of June, A. D. 1874.

HENRY R. ELLIOTT,
U. S. Com. for the Dist. of Col.

{Notarial Seal.}

Patent Office.

June 27, 1874.

U. S. A.

3. MOTION TO RE-OPEN.

In re-applications of Elisha Gray, Appl's for Transmitting Musical Tones by Telegraph referred with endorsements to the Hon. Commissioner.

H. C. TOWNSEND,
Ass't. Exr. in Chg.

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220 KINZIE STREET,
CHICAGO. Jan. 9, 1875.

The Honorable The Commissioner of Patents:

SIR—The two applications filed by Elisha Gray, in June last, for letters patent for an improved method of transmitting musical tones by electricity, and which were ordered to issue July 12, require amendment before the patents are issued, but, for various reasons, Mr. Gray has not been able to make these amendments up to this time, though he intends to do so in a few days.

I have therefore to request that the said applications be not forfeited by reason of the non-payment of the balance fees on January

12, six months from July 12, but that they be returned to the examiner for action upon the amendments, which I propose to present.

Respectfully,

ALEX. L. HAYES,
Attorney for Elisha Gray.

Patent Office,
Jan. 12, 1875.
U. S. A.

WASHINGTON, Jan. 12, 1875.

The Hon. The Commissioner of Patents:

SIR—In April and June last Elisha Gray, of Chicago, filed two applications for letters patent, for a "method of transmitting musical tones by electricity," which applications, after due examination, were passed for issue July 11, 1874; the balance fees on the same being due Jan. 11, 1875.

After the allowance of these applications it was found that the specifications did not adequately describe the inventions, and that amendments to the same were required, which for various reasons the inventor was unable to prepare up to January 9, at which date I intended to leave Chicago, so as to reach Washington on the 11th, and file the amendments before the forfeiture of the applications.

I was unable to leave until the 10th inst., and, therefore, on the 9th, addressed a letter to the Patent Office notifying of my intention to amend, and requesting that the applications be returned to the examiner, and relying upon this letter reaching the Patent Office on the 11th in due course of mail.

This letter was, however, not received until this morning, so that the applications were duly forfeited yesterday.

I have now to request that this delay in the mails which was not the fault of the applicant, shall not cause the forfeiture of his applications, but that his notification of his intention to amend be con-

sidered as if received on the 11th inst., and that the applications be returned to the examiner.

Respectfully,

ALEX. L. HAYES,
Attorney for Elisha Gray.

Leaving out of consideration the question as to whether a mere modification of intention to amend would justify the examiner in withdrawing a case from the issue, in order to save it from forfeiture, it would seem that if the analogous case of Henry H. Blake (Commissioner's Decisions for 1873, page 6), may be taken as a guide, the present applications must be held to be forfeited. The matter is, however, respectfully referred to the Commissioner.

H. C. TOWNSEND,
Asst. Exr. in Ch'g.

Patent Office.

Jan. 12, 1875.

U. S. A.

4. COMMISSIONER'S DECISION.

Recorded Vol. 15, p. 358.

In the matter of the applications of Elisha Gray, filed respectively April 18th and June 27th, 1874, "apparatus for transmitting sound."

MOTION.

The two applications were ordered to issue July 10th, 1874. The six months' limit within which the final fees should have been paid expired January 10th, 1875.

Applicant moves January 12th, 1875, that the applications be returned to the examiner for amendment, and submits in support

thereof a letter sent to the Commissioner, dated Chicago, January 9, 1875, asking for this action. This letter was not received in the office until January 12, and as already stated in the case of H. H. Blake, 3 Og., p. 2, the date of filing in the office of a paper must control action, and not the apparent date of the instrument. In this case it was impossible for the letter to reach the office, in ordinary course of the mails, within the six months.

The applications must be held to be forfeited, under Sec. 35, of the Patent Law. Under this section the Commissioner has no discretion; the fee must be paid within the time, if no action is taken changing the status of the applications before the office. The reason for this is evident; the rights of applicants are not finally determined by such forfeiture, but at any time within two years thereafter the applications may be revived, simply by the payment of new fees.

The motion is denied.

J. M. THATCHER,
Commissioner of Patents.

January 18, 1875.

RENEWAL OF APPLICATION.

PETITION.

($15 H.)

To The Commissioner of Patents:

Your petitioner represents that on June 27th, 1874, he filed an application for letters patent for a method of transmitting musical tones by electricity, which application was allowed July 11th, 1874, but that he failed to make payment of the final fee within the time allowed by law. He now makes renewed application for letters patent for said invention, and prays that the original specification, oath, drawings and model may be used as part of this application.

Respectfully,
ELISHA GRAY,
By his Attorney,
ALEX. L. HAYES.

Washington, January 19, 1875.

Patent Office,
Jan. 19, 1875.
U. S. A.

5. AMENDMENT A AND LETTER.

February 3, 1875.

WASHINGTON, February 2, 1875.

The Hon. The Commissioner of Patents:

SIR—In the matter of the application of Elisha Gray for letters patent for an improvement in apparatus for transmitting musical tones by electricity, filed June 27th, 1874, I hereby amend by canceling the specification except the signature—except the signature of the inventor, and substituting the enclosed.

ELISHA GRAY,
By his Attorney,
ALEX. L. HAYES.

Patent Office,
Feb. 3, 1875.
U. S. A.

To All Whom it may Concern:

Be it known that I, ELISHA GRAY, of Chicago, in the County of Cook, and State of Illinois, have invented a new and useful apparatus for transmitting musical vibrations by electricity, of which the following is a full, clear and exact description, reference being had

to the drawings accompanying and forming part of this specification:

This invention is based upon the observed fact in electrical science, that when an electric current is made to circulate *in a coil of wire surrounding a bar of iron, as, for instance, the core of an electro-magnet, said bar* on becoming a magnet will be slightly elongated by molecular action, and consequently if the currents succeed each other rapidly, the said bar or core will be made to vibrate, and if the rate of vibration exceeds a certain number of times per second, it will give out a musical tone.

Amd't A, February 3, 1875.

Upon this principle, an apparatus known as the "telephone" has been devised, and is described in Treatise on Electricity, in which a diaphragm, by being thrown into vibration by the production of a musical tone near the same, is made to break and close an electric circuit as many times per second as there are vibrations per second in the tone produced, which interruptions produce a musical tone of corresponding pitch in a (n) iron bar surrounded by coil of wire, at any distance from the diaphragm, on the principle above explained.

Erase and insert per Amd't B, June 22, 1875.

The apparatus is, however, of delicate construction, and does not always act with certainty.

My apparatus is an improved telephone, in which I make use of induced secondary currents from either a primary or secondary coil, for effecting the vibrating bar or core of the vibrating electro-magnet, and cause the necessary succession of said currents by interruptions in a primary circuit made by an automatic mechanical circuit-closer.

In the drawings accompanying this specification, Fig. 1, sheet 1, is a view showing the transmitting apparatus and its connections in plan, and the receiving apparatus in elevation, and Fig. 1, sheet 2, is a view showing the transmitting apparatus in perspective.

The apparatus is constructed as follows:

A is the frame or base of the apparatus at the transmitting station. B is an induction coil of the usual construction, having the usual primary and secondary circuits. C C^1 are automatic vibrating electrotomes of the usual construction in which the vibrating circuit closing springs are so adjusted, that when in action they produce musical tones, which, from the difference in adjustment, and in the length and thickness of the springs are of different pitch. The

2694

number of these electrotomes may be increased so that tones extending through two or more octaves may be produced.

D D are telegraph keys of the usual form, which are placed in the said primary circuit, and the primary circuit is so divided that a part of the circuit passes through each key and its corresponding electrotome.

Amd't A, February 3, 1875.

These keys make and break the battery connection.

The operation is as follows:

When a key is closed, the primary circuit will pass from the battery through one of the electrotomes C or C^1, and its connections corresponding to the key depressed, and the primary circuit will be automatically interrupted in usual manner.

Erase and insert per Amd't B, June 22, 1875.

The spring will therefore be thrown into rapid vibration as long as the circuit is closed at the key, and an audible tone of a pitch determined by the rate of vibration of the spring will be produced, while at the same time a series of induced currents corresponding in number to the number of audible vibrations in the tone will be induced in the secondary circuit of the induction coil B.

This circuit may be extended to any distance from the transmitting station. At the receiving station in said circuit is *placed an electro-magnet E, or a coil of wire surrounding a bar of iron*, and said bar or electro-magnet will vibrate as many times per second as there are interruptions in the current, and consequently will give forth a musical tone of the same pitch as that given by the circuit-closing spring as before explained.

S is a hollow cylinder of metal, which is placed on the poles of the magnet, and intensifies the sound produced by the same.

It is obvious that if a series of electrotomes is provided, connected as before stated, each of whose springs gives tones of different pitch, that the electro-magnet can be made to give forth corresponding tones by depressing the key and closing the circuit through the electrotome which gives any particular note, and this way the melody which can be produced by means of the electrotomes at the transmitting station can be reproduced on the electro-magnet at the receiving station.

By having a series of electrotomes or circuit-breakers with their corresponding induction apparatus and a series of receiving magnets connected in independent circuits, a musical composition containing chords can be transmitted, or the different parts of a composition, played simultaneously at different places

Am'd't A, February 3, 1875.

2395

can be reproduced at one place or by means of switches, the same or different parts of a composition can be played at different places at a distance from each other in turn.

Many other remarkable effects may be produced.

The advantage of using induced currents is, that they can be transmitted through considerable resistance owing to their high tension, and also, that they are more effective for magnetizing the electro-magnet, thereby enabling the apparatus to be operated with but small battery power.

Erase and insert per Am'd't B, June 22, 1875.

Mechanical circuit-closers may be used for making the necessary interruptions in the primary circuit of the induction apparatus, and instead of using the secondary current of the secondary coil, the secondary or extra current of a primary coil may be used.

The apparatus can be used for telegraphing on long land or submarine lines.

When used for telegraphing, letters and signals can be represented by tones differing in pitch, or Morse signals can be made by short and long interruptions in a prolonged tone of the same pitch.

What I claim as my invention, and desire to secure by letters patent, is:

FIRST. The method, substantially as described, of *producing musical tones* by the vibration of *a bar of iron surrounded by a coil of wire or an electro-magnet*, by transmitting a series of induced currents corresponding in number per second to the number of audible vibrations per second in the tone produced through said coil or electro-magnet.

Am'd't A, February 3, 1875.

SECOND. The combination of an apparatus producing induced secondary currents with a series of electrotomes or other circuit breakers, and an electro-magnet or series of electro-magnets arranged in said secondary circuit, substantially as and for the purpose set forth.

Erase and insert per Am'd't B, June 22, 1875.

2396

Patent Office,
Feb. 3, 1875.
U. S. A.

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6. ASSOCIATE TO HILL & ELLSWORTH,

WASHINGTON, D. C., March 16, 1875.

To The Commissioner of Patents:

SIR—I hereby authorize Hill & Ellsworth to examine any papers, &c., filed with the applications of Elisha Gray for telephone.

ALEX. L. HAYES,
Attorney for E. Gray.

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7. REJECTION.

March 29, 1875.

No. 1. 67–46–1.
Copy sent March 29.
I. R. A.
Send to Hill & Ellsworth.

EXAMINER'S ROOM, No. 118,
U. S. Patent Office,
Washington, D. C., March 29th, 1875.

E. GRAY,
Care A. L. Hayes,
Boston, Mass.

Apparatus for transmitting musical tones by electricity, filed June 27th, 1874, renewed January 19th, 1875.

Applicant's attention is called to the words "*or series of electro-magnets*" in second claim. These are substantially new matter not in claims originally allowed, and not based on anything in the specification. In fact, the main difference between this and applicant's later case, is, that in this one main circuit and *one receiver respond-*

'239'

ing to all notes is used, in the latter one, in one main circuit several receivers, each responding to one note only are used. The words quoted obliterate this distinction. With these words in the claim it is rejected.

Applicant's attention is called to the paragraph concerning mechanical circuit-breakers, on p. 7 of specification, and to the remarks on the subject in letter of this date in first case. Another app't shows, describes and claims what is therein suggested.

Z. WILBUR,
Examiner.

POWER OF ATTORNEY.

ELISHA GRAY, TRANSMITTING MUSICAL TONES BY ELECTRICITY.

Filed June 27, 1874.

Case 2.

(Form No. 6. Power of Attorney.)

In the United States Patent Office.

In the matter of the application of Elisha Gray, of Chicago, Illinois, for Letters Patent of the United States, for apparatus for transmitting musical tones by electricity, filed June 27, 1874.

WASHINGTON, June 11, 1875.

To the Commissioner of Patents:

The undersigned hereby makes, constitutes and appoints William D. Baldwin, of Washington City, in the District of Columbia, his attorney with full power and authority of substitution and revocation to prosecute said application, to make alterations and amendments therein, to receive the patent, and to transact all business connected therewith in the Patent Office; and hereby revokes any and all powers of attorney heretofore given.

Applicant sign:

ELISHA GRAY.

I concur in the above.

Assignees sign:

SAMUEL S. WHITE.

2398

Patent Office,
June 12, 1875.
U. S. A.

8. AMENDMENT B AND LETTER.

June 22, 1875.

In the United States Patent Office.

In the matter of the application of Elisha Gray, for letters patent for apparatus for transmitting musical tones by electricity, filed June 27th, 1874.

WASHINGTON, D. C., June 22, 1875.

To the Commissioner of Patents:

SIR—In view of official suggestions, an amended specification is herewith filed in the above-mentioned application, without waiving applicant's rights in the premises. Applications will hereafter be filed claiming the multiple transmitter, the mechanical circuit-breaker, and the organ pipe circuit interrupter.

Respectfully yours,
ELISHA GRAY,
By his Attorney,
WILLIAM D. BALDWIN.

2394

Patent Office,
June 22, 1875.
U. S. A.

Case 2.

(Form No. 2. Amendment.)

In the United States Patent Office.

In the matter of the application of Elisha Gray, for letters patent for apparatus for transmitting musical tones by electricity, filed June 27, 1874.

WASHINGTON, D. C., June 21, 1875.

To The Commissioner of Patents:

SIR—Amend the above-mentioned application as follows: Substitute for the specification heretofore filed the following:

To all whom it may concern:

Am'd't B, June 22, 1875.

Be it known that I, ELISHA GRAY, of Chicago, in the County of Cook, and State of Illinois, have invented a certain new and usefulapparatus for transmitting musical impressions or sounds telegraphically, of which I hereby declare the following to be a full, clear and exact description.

My invention relates to what I term an "electro-harmonic" telegraph, and is based upon the fact well known to electricians, that an electro-magnet elongates under the action of the electric current, and contracts again when the current ceases, consequently a succession of impulses or interruptions will cause the magnet to vibrate; and if these vibrations be of sufficient frequency, a musical tone will be produced, the pitch of which will depend upon the rapidity of the vibrations.

I have discovered that by interrupting an electric current at the transmitting end of a line with sufficient frequency to produce a musical tone by an instrument vibrated by said interruptions, and transmitting the impulses thus induced to an electro-magnet at the receiving end of the line, the latter will vibrate synchronously with the transmitting instrument, and thus produce a musical tone or note of a corresponding pitch.

The object of my invention is to utilize this discovery for the transmissions of intelligible signals to a distance by electricity; to which end my improvement consists in the combination of a telegraphic circuit, an automatic circuit-breaker capable of producing a musical tone; and an electro-magnet receiver, which reproduces the tone by being thrown into vibration by impulses generated by the circuit-breaker. My improvement further consists of the combination of a telegraphic circuit; a series of circuit-breakers capable of producing musical notes of different pitch, a series of keys for simultaneously or successively throwing said circuit-breakers into or out of operation, and an electro-magnet receiver, which is thrown into operation by the transmitter, whereby tones of different pitch may be reproduced at the receiving end of the line by the use of a single circuit.

Am'd't B, June 22, 1875.

Erase per Am'd't E, July 27, 1875.

In the accompanying drawings, figure 1 shows a plan view of the transmitting part of my improved apparatus, the receiver appearing in perspective. Fig. 2 is a view in perspective of the transmitter.

The transmitting apparatus is mounted upon a base board A, as usual. The induction coil B has the usual primary and secondary circuits. An ordinary automatic electrotome C has a circuit-closing spring *c* so adjusted as when in action to produce a musical tone, according to its length, thickness and adjustment. A common telegraph key D is placed in the primary circuit to make or break the battery connection.

In the drawings I have shown two electrotomes of identical construction, but of different pitch, and two keys; both the keys and the electrotomes being placed in the primary circuit, which is so divided that part of the circuit passes through each key and its corresponding electrotome. The number of electrotomes may be increased so that tones extending through two or more octaves may be produced. An ordinary electro-magnet is provided at the receiving end of the line.

2401

The operation of the aparatus is as follows:

In the arrangement shown in the drawings, when a key is closed, the primary circuit will pass from the battery H, through that key and its corresponding electrotome, and will be automatically interrupted in the usual manner. The spring of the electrotome will thus be caused to vibrate rapidly and to produce a tone, the pitch of which is determined by the rate of vibration. It is obvious that several keys may be depressed simultaneously. These vibrations or interruptions of the current will simultaneously produce, in the secondary circuit of the induction coil, a series of induced currents or impulses corresponding in number with the vibrations of the electrotome; and, as the receiving electro-magnet is connected with this circuit, it will be caused to vibrate, thus producing a tone of corresponding pitch, the sound of which may be intensified by the use of a hollow cylinder S, of metal, placed on the poles of the magnet.

Am'd't B, June 22, 1875.

When a single electrotome is thrown into action, its corresponding tone will be reproduced on the sounder by the magnet. When electrotomes of different pitch are successively operated, their tones will be correspondingly reproduced by the receiver; and when two or more electrotomes are simultaneously sounded, the tone of each will still be reproduced without confusion on the sounder, by which means I am enabled to reproduce melodies or tunes.

Mechanical circuit-breakers might be substituted for the automatic vibrating electrotome hereinbefore described, and I have in fact used such mechanical circuit-breakers, of various construction, but I found the electrotome more satisfactory, in practice.

In this instance the receiver is shown and described as operated by the induced current of the secondary coil; but the secondary or extra current of a primary coil may be used instead thereof with good effect.

My apparatus is especially adapted to telegraphing on long land and submarine lines. By it, letters and signals can be represented by tones, differing in pitch, or the ordinary Morse signals can be made by short and long interruptions in a prolonged tone of the same pitch, thus securing great raipdity of transmission.

An application for letters patent of the United States, filed by me April 18, 1874, shows an apparatus somewhat similar to the one herein described for transmitting musical tones through animal tissue to a resonant electrical receiver; I do not therefore claim herein anything therein shown.*

*Insert per Am'd't C, July 20, 1875.

I claim as my own invention:

Am'd't B, June 22, 1875.

The improved apparatus for transmitting musical impressions or sounds telegraphically, hereinbefore set forth, consisting of the combination of a telegraphic circuit, an automatic circuit-breaker capable of producing a musical tone, and an electro-magnet receiver which reproduces the tone by vibrations caused by impulses generated by the circuit-breaker, substantially as described.

Erase per Am'd't G, July 24, 1875.

(I also claim†) the combination of a telegraphic circuit, a series of circuit-breakers capable of producing musical tones of different pitch, a series of keys for simultaneously or successively throwing said circuit-breakers into or out of operation, and an electro-magnet receiver, which is thrown into operation by the transmitters; whereby tones of different pitch may (simultaneously or successively‡) be reproduced at the receiving end of the line by the employment of a single circuit.

†Erase per Am'd't H, July 24, 1875.

‡Erase per Am'd't D, July 20, 1875.

ELISHA GRAY.

Witnesses:

E. C. DAVIDSON.
WM. J. PEYTON.

DISTRICT OF COLUMBIA, ss.:

ELISHA GRAY, whose application for letters patent for apparatus for transmitting musical tones by electricity was filed in the United States Patent Office, on or about the 27th day of June, 1874, being duly sworn, deposes and says that in addition to the claims originally made, he verily believes himself to be the original and first inventor of the improvement as described and claimed in the foregoing amendment, and that he does not know, and does not believe that the same was ever before known or used.

ELISHA GRAY.

Sworn to and subscribed before me this 21st day of June, 1875.

DELOZIER DAVIDSON,
Notary Public.

{Notarial Seal.}

7105

Patent Office,
June 22, 1875.
U. S. A.

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9. OFFICE LETTER.

July 7, 1875.

(No. 1.)
Copy sent July 7th,
I. R. A.

EXAMINER'S ROOM No. 118,
U. S. Patent Office,
Washington, D. C., July 7, 1875.

ELISHA GRAY,
Care W. D. Baldwin,
Present.

TRANSMITTING MUSICAL TONES BY ELECTRICITY.

JANUARY 19, 1875.

The first claim in this case covers matter interfering with other applications on file.

The second is thought to be clear of interference covering the combination with several transmitters of one receiver. The distinction would be clearer, were the words "one electro-magnet receiver thrown into operation by the impulses sent from any of the transmitters" substituted for "an electro-magnet receiver," &c. In the latter part of second claim occur the words "simultaneously or successively," it is not seen how applicant's single receiver reproduces "simultaneously" several notes or tones.

Upon the subject of a disclaimer, reference is made to letter in other (original case) of even date herewith.

Z. WILBER,
Examiner.

2404

10. AMENDMENTS C. D.

July 20, 1875.

United States Patent Office.

In the matter of the application of Elisha Gray, for letters patent for transmitting musical tones by electricity, filed Jan. 19, 1875. Originally filed June 27th, 1874.

(Case 2.)

WASHINGTON, D. C., July 20, 1875.

To the Commissioner of Patents:

SIR—Amend the specification of the above-mentioned application as follows:

After page 5, insert the following disclaimer:

"Neither do I claim herein the combination with a main line of an intermittent circuit-breaker or a series thereof, each adapted to throw upon the line a definite number of electrical impulses per unit of time, and a key or keys, one for and controlling each such circuit-breaker, as it constitutes the subject matter of another application filed by me, February 23, 1875."*

Am'd't C, July 25, 1895.

*Insert per Am'd't H, July 25, 1875.

Claim 2, lines 9 and 10 erased ("simultaneously or successively").†

†Am'd't D, July 20, 1875.

The above amendments are submitted in view of the official letter of July 7, 1875. The first claim, it will be observed, is for the improved apparatus set forth, and embodies one electro-magnet receiver only, there being no other shown or described.

A re-examination is therefore requested to determine whether, in view of this fact, applicant is not entitled to the claim without an interference.

Respectfully,

ELISHA GRAY.

By his Attorney,

WM. D. BALDWIN.

12405

Patent Office,
July 20, 1875,
U. S. A.

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11. AMENDMENTS E, F, G, H.

July 24, 1875.

In the United States Patent Office.

In the matter of Application of Elisha Gray, for letters patent for transmitting musical tones by electricity, filed Jan. 19th, 1875. Originally filed June 27th, 1874.

(Case 2.)

WASHINGTON, D. C., July 24, 1875.

To the Commissioner of Patents:

Amend the specification of the above-mentioned application as follows:

Am'd't E, July 24, 1875. (Page 2, cancel lines 17 to 23, both inclusive.)

Insert immediately before the claim and after the disclaimer of July 20th, 1875, the following:

"The combination of a telegraphic circuit, an automatic circuit-breaker, capable of producing a musical tone and an electro-magnet Am'd't F, July 24, 1875. receiver, which reproduces the tone by being thrown into vibration by impulses generated by the circuit breaker, is not broadly claimed herein, as this combination constitutes a part of the subject matter of said application also."

†Am'd't G, July 24, 1875. Page 6 (cancel the first clause of claim).†

‡Am'd't H, July 24, 1875. Page 6, line 11, erase ("I also claim").‡

Very respectfully,
ELISHA GRAY.
By his Attorney,
WM. D. BALDWIN.

2406

Patent Office,
July 24, 1875,
U. S. A.

Memorandum of fee paid at U. S. Patent Office.

Inventor, E. Gray.
Patent to be issued to
Invention,
Transmitting Musical Tones by Electricity (Case 2).
Date of payment,
July 24th, '75.
Second fee,
$20.
Solicitor,
Wm. D. Baldwin.

1874.

Renewal (50).
Wilbur 67

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46

No. 166,095.

Div. 16.
Elisha Gray.

Of Chicago.
County of Cook.
State of Illinois.
Apparatus for Transmitting Musical Tones by Electricity.
Rec'd June 27th, 1874.
Rec'd January 19, 1875.
Petition, June 27, 1874.
Petition, January 19, 1875.

2407

Affidavit, June 27, 1874.
Specification, June 27, 1874.
Drawing 2 sheets, June 27, 1874.
Model in applicant's pending case.
Cert. dep.
1 Cash, $15, June 27, 1874.
Cash, $15, January 19, 1875.
Add'l Fee Cert.
1 Add'l Fee Cert., Cash, $20, July 24, 1875.
Examined, July 10, 1874, Wilbur.
Examined, July 24th, 1875, Wilbur.
2 Issue, July 24th, 1875, Knight.
4 Patented, July 27, 1875.
Recorded, Vol. , page .
Circular, July 11, 1874.

W. D. BALDWIN,
Present.

1874.

CONTENTS.

1 Application, 1 paper.
2 Passed July 10th, '74.
3. Motion to reopen, January 12th, '75.
4. Commissioners Decision, January 18th, '75.
5. Amendment A and letter, February 3d, '75.
6. Authorizing H. & E. Asso. Att'y. } March 6th, 1875.
7. Rejection, March 29th, 1875.
8. Amendment B and Letter, June 22d, '75.
9. Letter, July 7th, 1875.
10. Amendments C, D, July 20th, '75.
11. Briefed, July 24th, 1875.
12.
13.
14.
15.
16.
17.

2404

18.
19.
20.

Title:

IMPROVEMENT IN ELECTRIC TELEGRAPHS FOR TRANSMITTING MUSICAL TONES.

(No. 54e.) Defendants' Exhibit, "Gray's Printer Patent." J. A. W., Sp. Examiner.

[Introduced in Record, p. 12.]

ELISHA GRAY, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO THE HARMONIC TELEGRAPH COMPANY, OF NEW YORK CITY.

IMPROVEMENT IN ELECTRO-HARMONIC PRINTING TELEGRAPHS.

Specification forming part of Letters Patent No. 179,549, dated July 4, 1876; application filed April 12, 1876.

To all whom it may concern:

Be it known that I, ELISHA GRAY, of Chicago, in the County of Cook, and State of Illinois, have invented a new and useful art of Electro-Harmonic Telegraph Printing and an Improved Electro-Harmonic Telegraph Printing Apparatus, of which the following is a specification:

My present invention is based upon a system of electro-harmonic telegraphy, described in sundry letters patent of the United States granted to me within the past year, and in various applications for letters patent of the United States made by me and now pending.

The objects of invention are, first, to adapt my electro-harmonic system of telegraphy to the printing of a message by means of independently movable type, and by means of mechanism thrown into action by the depression of a key at the transmitting station, without necessitating the employment of isochronously moving type wheels, or of waiting for mechanism to register accurately before printing; second, to print a message on the letter sheet, type-writer fashion, by the direct operation of keys at the transmitting station controlling local batteries actuating the printing mechanism; third, to transmit a series of tones of different pitch through an electric circuit, each tone independently actuating a local battery, to print a letter, sign or character corresponding with that of the particular key controlling the tone; fourth, to determine in advance, through the action of a local battery, which one of the series of letters, numbers or characters actuated by a common motor shall be printed; fifth, to determine in advance the point on the letter sheet at which the printing of the message shall begin; sixth, to move a particular type to the point at which the printing is done, and there

2410

to make its impression upon the paper by means of mechanism thrown into action by the movement of the type itself; seventh, to feed the paper upon which the message is printed by mechanism thrown into operation by the printing of the preceding letter; eighth, to determine in advance what particular letter of a series shall be printed, to actuate the printing mechanism by the movement of the particular type selected, and to actuate the feeding mechanism by the type thus selected; and, ninth, to control the printing mechanism by means of a compound magnet, constituting in fact a single one.

These objects I attain by certain novel apparatus hereinafter set forth, the novel construction and combinations of which apparatus form a portion of the subject matter of my invention, which is hereinafter specifically designated.

The accompanying drawings represent an apparatus embodying all my improvements in the best way now known to me. Obviously, however, the details of construction of the apparatus may be greatly varied in various ways without departing from the principle of my invention; and some of my improvements may be used without the others, and in apparatus differing in construction from that herein shown.

My improved apparatus consists of two main portions—a transmitter and a receiver.

Figure 1 represents a plan or top view of the transmitter, with portions of the casing removed to show the internal construction more clearly. Fig. 2 represents a vertical longitudinal section through the transmitter, on the line 1 1 of Fig. 1. Fig. 3 is a bottom plan view of the transmitter, showing the method of running the circuits. Fig. 4 is a back view of one set of transmitting reeds. Fig. 5 is a diagram showing the method of running the main and local circuits through a single transmitting key and vibrating reed of a series. Fig. 6 is a plan or top view of the receiving apparatus, on the line 2 2 of Fig. 10. Fig. 7 is a bottom plan view of the top plate of the receiver. Fig. 8 is a vertical longitudinal section therethrough, on the line 4 4 of Fig. 7. Fig. 9 is a transverse section on the line 5 5 of Fig. 8. Fig. 10 is a vertical longitudinal section on the line 3 3 of Fig. 6. Fig. 11 is a top view of the apparatus for carrying the paper, and Fig. 11^a is a vertical transverse section therethrough on the line 6 6 of Fig. 11. Fig. 12 is a detailed view of a portion of the local circuit-breaking mechanism which releases the paper-carrying mechanism. Fig. 13 is a similar view of another

portion of the same apparatus. Fig. 14 is a detailed view of the paper-feeding apparatus for spacing the lines of the message. Fig. 15 is a bottom plan view of the parts shown in Fig. 6, showing the mode of running the circuits. Fig. 16 is a detailed view showing the method of running the circuits of the printing and paper-feeding mechanism. Fig. 17 is a skeleton diagram of the receiving and transmitting mechanisms, showing the method of connecting the circuits. Fig. 18 is an end view, and Fig. 19 a side view, of the compound analyzing receiver. Figs. 20 and 21 are detailed views of the shunting pins of the analyzing spring, and Fig. 22 shows a plan view of a star wheel for actuating the type-shifting levers detached.

The transmitting apparatus shown in the accompanying drawings is substantially similar, in its general construction, to that shown in Letters Patent of the United States granted to me February 16, 1876, as No. 173,618, with the exception hereinafter stated.

In this instance the apparatus is designed for printing twenty-seven characters, and for operating a tripping apparatus whereby the printing mechanism at the receiving end of the line may be automatically restored to its normal position during any portion of its operation of printing a line.

In order to avoid the complication of using twenty-eight different keys and their corresponding transmitting reeds, I have devised means whereby the whole twenty-eight characters may be transmitted by the employment of nine primary keys, three shifting keys, and a "trip key," thus reducing the number of keys employed more than one half.

The primary keys are each marked with three letters, numbers or characters, and together with the trip-key and shifting keys are arranged organ-fashion, as shown in Fig. 1, on a suitable base-board or frame A, upon which the transmitting-reeds are mounted, in the manner shown in the drawings.

In order to secure convenience of construction, and a compact arrangement, the series of transmitting reeds are arranged in two sets B B′, of similar construction mounted upon the base-board of the frame, as shown.

The broken lines in Fig. 1 represent the connection of the keys with the transmitters. Fig. 3 shows a view of the connections as arranged beneath the base-board directly under the transmitters. Fig. 5 shows a method in which the main and local batteries are connected with a single key and vibrating reed of the circuit. Each

one is a duplicate of the other, and their circuit connections are substantially similar to those shown and described in my patent of February 16, 1876, above mentioned; and as they, moreover, will be readily understood from the figure, a detail description of the construction and operation of these parts is deemed unnecessary.

In the operation of this apparatus the circuit is normally open, but the depression of any key connects the main battery to line through its corresponding transmitter. Each of the thirteen keys above mentioned has its own independent analyzer at the receiving end of the line.

In the present arrangement the organization is such that there are twenty-seven printing type at the receiving end of the line, corresponding with the lettered keys, as will hereinafter be more fully explained.

These type are arranged in sets of three, one of each set being operated by each lettered key. Which one of these three letters shall be printed is determined by depressing one of the shifting keys 1, 2, 3, which operate the type-shifting mechanism of the receiver in such manner that, in the present instance, when the key 1 is depressed, the depression of the lettered keys will print the letters on the row included between the letters E and N in Fig. 1. When key 2 is depressed the middle row of letters only will be printed at the receiving end of the line; and when key 3 is depressed, the type corresponding with the outer row only will be acted upon. When the key marked "trip" is depressed, it operates to restore the paper-carrying mechanism to its normal position or starting point, as will be hereinafter more fully explained.

In the organization shown in the drawings the keys 1, 2, 3, are operated independently of the lettered keys or trip-key; but when either of said numbered keys is depressed, it makes no difference where the lettered keys are touched, as they can only print the letter of the row corresponding with the numbered key depressed.

As a modification of this device I contemplate so constructing and combining the keys that each letter shall be mounted on an independent movable section, attached to the key by a movable connection, in such manner that when a particular letter is depressed it shall operate the correspondingly numbered key, and thus cause it to shift the proper type without the necessity of touching both the lettered and the trip-key, as is necessary under the organization shown in the drawings.

This result can readily be attained in two ways: first, by means

of a contact point on the key which shall close the circuit or tone of the properly numbered key, thus actuating the type-shifter at the receiving end of the line before the lettered key closes its own circuit to actuate the type. This result may also be attained by combining levers or other suitable devices connecting each key with the contact point of the numbered key, although I prefer the first mentioned plan, as being less complicated.

The manner in which the transmitters and receivers are connected will readily be understood by inspection of Fig. 17, in which 1, 2 and 3 represent the numbered keys and N W a lettered key, should be stated, however, that the local battery of the transmitter is omitted in this figure to avoid complication, but it is shown in Fig. 5. The depression of either key closes both the main and local circuits of the transmitter, and sends to line vibrations or impulses of the electrotome or vibrating reed corresponding with the key. These vibrations pass through the magnet C C^1, of the analyzing receiver, and are reproduced on the corresponding vibrating tuned bar or reed 1, 2, 3, or N. W. Each bar is provided with a circuit-breaking lever B, vibrating more slowly than the bar, as described in Letters Patent No. 166,094, granted to me July 27, 1875. These circuit-breaking levers control a local battery, L B No. 1, which remains normally closed and in short circulited through the vibrating bars or analyzing springs and levers above mentioned. Each analyzing spring is provided with a loop passing through a corresponding local magnet, 1, 10, 11, or 12, the terminals of which loop connect, respectively, to the analyzing spring and with its circuit-breaking lever, so that when the circuit-breaking lever is out of contact with its vibrating bar, the shunt or short circuit is taken off from its corresponding magnet, and the current flows through the magnet; but when the vibrating bar and circuit-breaking lever are in contrct, the shunt comes into play and no current passes through the magnet.

The circuit-breaking devices, as above remarked, are shown in my patent of July 27, 1875; but the method of running the circuits and actuating the magnets herein shown is new.

Four vibrating bars only are shown on Fig. 17 to avoid complication, but will, of course, be understood that the bars will correspond in number with their transmitting keys—that is to say, in the present instance, there would be thirteen in number, each bar having its own loop and local magnet. In this instance nine magnets are employed for actuating the type—three for the shifting mechanism, and one for the tripping mechanism.

2414

In Fig. 6 the relative arrangements of the nine type actuating magnets 1 to 9, and the shifting magnets, 10, 11 and 12 are clearly shown.

Having thus indicated in a general way the method of running the circuits, I will now proceed to describe the details of the receiving apparatus.

I will first describe the compound magnet C C^1, by which the vibrating bars are actuated.

In another application for letters patent of the United States filed by me simultaneously herewith, I have shown a different method of mounting a series of vibrating bars or analyzing receivers, each tuned to a different pitch upon a common magnet, so that each will analyze its own tone from a series simultaneously transmitted through the single magnet. I do not, therefore, broadly claim in this application this device, except in combination with other mechanism not shown in the application above mentioned. In this instance the magnets C C^1 are mounted upon bars C^2 C^3 connecting, their respective poles and mounted in a frame D (see Figs. 18 and 19), which also show a method of mounting the vibrating bars and circuit-breaking springs.

It should be observed that the bar marked 14 in Fig. 18 is inoperative in the organization hereinbefore described, having no corresponding transmitter. The bars are connected with the frame by means of insulated pins D D^1 (shown in Figs. 20 and 21), one set of pins being made adjustable, as shown in Figs. 18 and 19, by set screws, or otherwise, and admit of the proper tuning of the bars to correspond with their transmitters.

I will now proceed to describe the organization I have effected for actuating the type-shifting and type-actuating mechanism, so as to cause one lever to actuate either one of three type.

Fig. 7 represents a plan view of the type bed showing a series of guideways or grooves radiating from a common centre, in each of which a type slides freely endwise. In the present instance the organization is such that each type successively moves to a common centre and is struck up against a platen to make an impression on the paper carried thereby, and is then retracted out of the way of the succeeding one, all these operations being performed automatically. In this instance the type is shown as made in the form of a bent lever, with the letter put on the end of the short arm of the lever, as moving forward radially to their working position, and then, being struck laterally to make their impression, retracting in

the same way as they advance. The type are actuated by a vibrating shifter lever, which I will now describe.

The details of the shifting mechanism are shown in Figs. 6, 7, 8, 9, 10, 17 and 22. In this instance the twenty-seven type shown in figure 7 are arranged in sets of three, corresponding with the respective transmitting keys.

The operation of the type-shifting and printing mechanism will readily be understood by reference to Fig. 17 which shows the three type-shifting keys 1, 2, 3, and a letter key, N W. If it is desired to print the letter N the key 1 is first depressed, thus sending vibrations to line synchronizing with the fundamental of the reed 3a. This takes off the shunt from the corresponding loop at the point where the vibrating lever *b* comes in contact with the bar, and allows the current of the local battery to pass through the magnet 10 of the series of shifting magnets 10, 11 and 12. A lever, E, on the armature of this magnet is thus attracted toward it and vibrates a shifter frame, E′, upon a vertical rock shaft *f*, carrying a star wheel F, having nine arms radially slotted to correspond with each set of the type actuating magnets 1 to 9 inclusive. On the armature of each of these magnets is mounted a rod L, movable radially, and endwise in the frame M, and carrying upon it a rocking shifter bar projecting both above and below it. The lower end of this bar slides in the corresponding slot in the star wheel above mentioned, while its upper end moves in a path coincident with one or the other of the type-slides in which it is adapted to work, as shown in Fig. 9.

Now when the armature lever E is attracted, as above explained, the rocking of the shifting frame E′ causes a partial rotation of the star wheel, which correspondingly shifts the position of the whole series of shifter bars. In this instance the bar described would be shifted to the position shown in dotted lines, Fig. 9, marked with the letter N, which would correspond with the position of that letter in Fig. 7 and each shifter bar would occupy the same relation to the letters included between E and N of Fig. 1. Were the shifter bar vertical or on the letter W, each shifter bar would occupy a corresponding relation to the middle row of letters in Fig. 1, and so in regard to the outer row. This movement takes place before the type actuating mechanism begins to operate, and consequently this movement is exerted upon the type or series of types previously determined by the shifting mechanism.

The armature H of the magnet 1 is connected with and actu-

2416

ates the slide bar above mentioned, which carries the shifter bar. In this instance as soon as the shifting bar is shifted in line with the type the armature H is attracted by the magnet 1 which forces the sliding rod L and shifter forward against the type, thus driving it forward in its groove to the central point of the machine where the impression is made. At this moment a contact point *i*, on the armature H, strikes a point which closes the circuit of the independent local battery and actuates a series of electro-magnets, 15, 14 and 13, the two latter operating on one armature. The attraction of the armature 1 by the magnet 15 throws up a printing lever I′ which strikes the type up against the paper carried on a platen J, and makes the impression at the same time the magnets 13 and 14 draw down their armature K, Fig. 10. Which retracts the pawl *k* operating on a spur-pinion L, gearing into a feeding rack *l*, connected with the paper-carrying mechanism. As soon as the key is released at the transmitting station the circuit is shunted, thus releasing the type actuating armature of the magnet figure 1, and breaking the circuit of the printing and paper-feeding magnets 13, 14 and 15, which allows the type to drop and be retracted by its spring M′ to its normal position. A spring *k*′, then retracts the armature K of the magnets 13 and 14, forcing the pawl forward and actuating the feed bar and moving the paper-carrying mechanism forward a distance sufficient to afford space for the next letter, in a manner similar to an ordinary writer. This process is repeated with each successive letter.

When the paper carrying mechanism has been fed along a distance equal to the length of the line which the machine is adjusted to print, the feed carriage N strikes a lug *o* on a sliding bar, O, and moves it endwise in its frame until its point *o*′ comes in contact with a spring *p*, which closes the local battery of the magnet 16. This draws down an armature mounted on a lever, R, rocking on a pivot *r*, and carrying the gear wheel above mentioned, which actuates the feed bar. The drawing down of the armature lifts this gear out of contact with the feed bar, and the paper-carrying mechanism is immediately retracted by the spring F′. The platen in this instance consists of a roller around which the paper passes, which roller rotates in bearings in the sliding carriage. During its forward movement the platen is prevented from rotating by means of a series of pins, *s*, on a wheel, S, on the same axis as the platen, which pins pass on each side of a guide bar S′. On the backward movement of the sliding carriage, however, one of these pins

strikes against a pivoted spring-switch, *t*, under the guide bar, which deflects the pins and turns the platen a distance equal to that desired for the distance between the rows of type. On the next forward movement of the feeding carriage the point of the *s* spring switch yields to allow the pin to pass without turning the platen, and as soon as the pins pass the point of the switch, it is thrown open again by a spring in readiness for the next backward movement of the carriage after the printing of the line is completed.

The carriage can be thrown back at any desired point in the line by pressing the trip key of the transmitter, which, through a corresponding analyzing spring in the receiver, throws the local circuit into connection with the magnet 16 in the same manner as that described as taking place by the operation of the sliding bar, thus releasing the sliding carriage and allowing it to return to its starting point.

It will thus be observed that the operator at the transmitting station is not only enabled to print at the receiving station any letter desired and automatically to shift the paper to commence a new line, type-writer fashion, but he is also enabled to shift the sliding carriage at the receiving station at will by means of his trip-key to commence a new line.

I propose to employ a ribbon fed between the paper and the type by well-known mechanical means, such as commonly used in type-writers, which, to avoid complication, is not shown in the drawings, and which needs no description.

I contemplate using a web or long strip of paper, so as to dispense with the constant watching of the receiving instrument, by the attendant, and by means of the trip-key above mentioned the paper can be fed along, so as to leave a space between each message, to permit of their being separated and delivered without rewriting.

I am thus enabled by my invention not only to print a telegraph message without the use of a type-wheel and without the use of synchronously moving step by step (or steadily revolving) mechanism, such as has heretofore been universally employed, so far as my knowledge extends, and thus save the time necessary for the type to come into position, the operator's ability to transmit being, thus, by my invention, the only limit to the speed of the apparatus.

I am also enabled by my invention to print messages in the form of a page or letter sheet in contradistinction to printing, in a single line and on a narrow strip as heretofore has been the case.

I am further enabled to determine in advance by the transmission of one tone, which one of the series of type shall move to make its impression, by throwing it into connection with mechanism actuated by the tone appropriated to the particular type to be printed.

I claim as my invention—

1. The hereinbefore described art of electro-harmonic telegraph printing, which consists in printing each letter at the receiving station by the direct and instantaneous action of a local battery controlled by a key at the transmitting station corresponding with said letter.

2. The hereinbefore described art of electro-harmonic telegraph printing which consists in printing a message on a letter sheet, type-writer fashion, by the direct operation of the keys at the transmitting station controlling local batteries actuating the printing mechanism.

3. The hereinbefore described art of electro-harmonic telegraph printing which consists in transmitting tones of different pitch through an electric circuit by means of corresponding keys, and reproducing said tones at the receiving station as a means of actuating local batteries controlling printing mechanism, which prints a letter corresponding with that of the key controlling the particular tone which throws the local battery into operation.

4. The hereinbefore-described art of electro-harmonic telegraph printing, which consists in determining in advance, through the action of one local battery, which one of the series of letters, numbers or characters shall be printed by mechanism actuated by another local battery.

5. The improved art of electro-harmonic telegraph printing, which consists in determining in advance, by means of one local battery, the point at which the printing of the message by another local battery shall begin.

6. The hereinbefore-described art of electro-harmonic telegraph printing, which consists in throwing forward a particular type to be printed by one local battery, and making an impression by that particular type by another local battery, automatically thrown into action by the movement of the type.

7. The hereinbefore-described art of electro-harmonic telegraph printing which consists in feeding forward the paper upon which the message is printed by mechanism thrown into operation by a local battery controlled by the printing of the preceding letter.

8. The hereinbefore-described art of electro-harmonic telegraph printing, which consists in touching a key which transmits a particular tone, by which one local battery determines in advance what particular letter shall be printed; carries forward the type selected, which in turn actuates another local battery, which makes the impression and controls the feeding mechanism.

9. The combination, substantially as hereinbefore set forth, of a reciprocating type, moved in one direction by the armature of the electro-magnet and in the other by a spring.

10. The combination, substantially as hereinbefore set forth, of the armature of the magnet, the endwise moving frame, the type printed thereon, and the retracting spring attached directly to the type.

11. The combination, substantially as hereinbefore set forth, of a series of type, movable radially relatively to a common centre, a shipper acting upon one of the series, and a series of electro-magnets which control the action of the shipper.

12. The combination, substantially as hereinbefore set forth, of a series of type, a carrier or shifter bar acting upon either one of said type, a series of electro-magnets which control the selection of the type to be acted upon, and a second electro-magnet, which actuates the type selected.

13. The combination, substantially as hereinbefore set forth, of a series of type, a shifting carrier acting upon one of the types of the series, a series of electro-magnets which select the type to be acted upon, a second electro-magnet which actuates the type selected, and a third electro-magnet, which actuates the printing hammer, to make an impression of the selected type.

14. The combination, substantially as hereinbefore set forth, of an electro-magnet for actuating the printer hammer, and an electro-magnet for actuating the paper feeding mechanism.

15. The combination, substantially as hereinbefore set forth, in an electric circuit of a vibrating reed, producing a musical tone or a definite number of vibrations per unit of time, a key controlling said vibrations, a corresponding reed at the receiving end of the line, a local battery controlled by said vibrating reed or circuit-breaker and an electro-magnet, the armature of which carries a type, for the purpose specified.

16. The combination, substantially as hereinbefore set forth, in an electric circuit of a series of circuit-breakers capable of producing tones of different pitch, a series of corresponding receivers, a se-

2470

ries of keys controlling the transmission of said tones, a series of local batteries controlled by the vibrating receivers, and a series of type controlled directly by the electro-magnets of the local batteries.

17. The combination, substantially as hereinbefore set forth, in an electric circuit of a series of transmitting keys, printing mechanism controlled by said keys, and a shifting key for determining in advance which letter of a series, marked on each key, shall be printed.

18. The combination, substantially as hereinbefore set forth, in an electric circuit of printing mechanism, keys controlling said printing mechanism, and a trip key, which determines the point at which the printing of the message begins.

19. The combination, substantially as hereinbefore set forth, in an electric circuit of printing mechanism, keys for controlling the printing mechanism, keys for determining which one of a series of type shall be printed, and a trip key which determines the point on the paper at which the printing shall begin.

20. The combination in an electric circuit, substantially as hereinbefore set forth, of apparatus for transmitting tones of different pitch, keys controlling said apparatus, receivers which analyze and reproduce said tones, and independently movable type, each controlled by its particular tone.

21. The combination, substantially as hereinbefore set forth, of a paper carrier, a spring for moving it in one direction, a feed bar, and gear wheel mounted on the armature of the electro-magnet, and adapted to be thrown into or out of gear with the feed bar by the movement of the armature.

22. The combination of the paper-carrying mechanism, a feed-bar, a gear wheel actuating said bar mounted on the armature of one electro-magnet, and a feed-pawl mounted on the armature of another electro-magnet.

23. The analyzing receiver, hereinbefore described, consisting of the combination of two or more magnets, with their light poles united by connecting bars, constituting in fact one magnet, and a series of tune-receiving springs vibrating near said bars, so that each shall receive its proper tone from said magnet.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

WM. A. SKINKLE,

WM. J. PEYTON.

2420

ries of keys controlling the transmission of said tones, a series of local batteries controlled by the vibrating receivers, and a series of type controlled directly by the electro-magnets of the local batteries.

17. The combination, substantially as hereinbefore set forth, in an electric circuit of a series of transmitting keys, printing mechanism controlled by said keys, and a shifting key for determining in advance which letter of a series, marked on each key, shall be printed.

18. The combination, substantially as hereinbefore set forth, in an electric circuit of printing mechanism, keys controlling said printing mechanism, and a trip key, which determines the point at which the printing of the message begins.

19. The combination, substantially as hereinbefore set forth, in an electric circuit of printing mechanism, keys for controlling the printing mechanism, keys for determining which one of a series of type shall be printed, and a trip key which determines the point on the paper at which the printing shall begin.

20. The combination in an electric circuit, substantially as hereinbefore set forth, of apparatus for transmitting tones of different pitch, keys controlling said apparatus, receivers which analyze and reproduce said tones, and independently movable type, each controlled by its particular tone.

21. The combination, substantially as hereinbefore set forth, of a paper carrier, a spring for moving it in one direction, a feed bar, and gear wheel mounted on the armature of the electro-magnet, and adapted to be thrown into or out of gear with the feed bar by the movement of the armature.

22. The combination of the paper-carrying mechanism, a feed-bar, a gear wheel actuating said bar mounted on the armature of one electro-magnet, and a feed-pawl mounted on the armature of another electro-magnet.

23. The analyzing receiver, hereinbefore described, consisting of the combination of two or more magnets, with their light poles united by connecting bars, constituting in fact one magnet, and a series of tune-receiving springs vibrating near said bars, so that each shall receive its proper tone from said magnet.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

WM. A. SKINKLE,

WM. J. PEYTON.

24/31

E. GRAY.

Receiver for Electro-Harmonic Telegraphs.

No. 198,379. Patented Dec. 18, 1877.

Fig 1

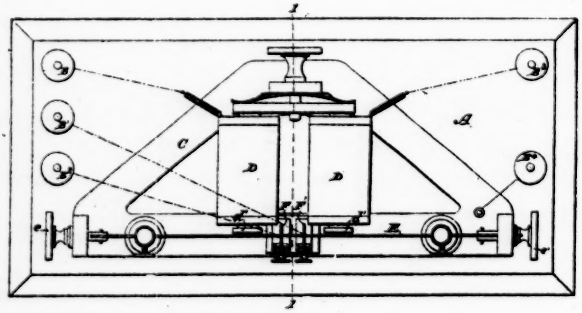


Fig 2

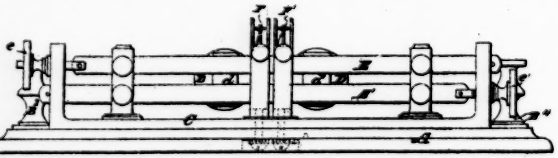
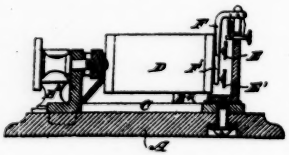


Fig 3.



WITNESSES

Wm A Skinkle
F. Stith

Per his Attorney

INVENTOR

Elisha Gray
Wm. Baldwin

(No. 54f.) Defendants' Exhibit, "Gray Double Bar Magnet Patent."

J. A. W., Sp. Ex'r.

(Introduced in Record, p. 12).

ELISHA GRAY, OF CHIGAGO, ILLINOIS, ASSIGNOR BY MESNE ASSIGNMENTS, TO THE HARMONIC TELEGRAPH COMPANY OF NEW YORK CITY.

IMPROVEMENTS IN RECEIVERS FOR ELECTRO-HARMONIC TELEGRAPHS.

Specifications forming part of Letters Patent, No. 198,379, dated December 18, 1877; application filed April 12, 1876.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois, have invented certain new and useful Improvements in Receivers for Electro-Harmonic Telegraphs, of which the following is a specification:

My invention relates to an analyzing receiver having two or more analyzing springs or bars, combined with a single electro-magnet, and constitutes an improvement upon the instruments shown in Letters Patent No. 166,094, granted to me July 27, 1875; the improvement consisting in combining two or more analyzing springs or ribbons, with separate adjustment, with the magnet, instead of the single bar or ribbon shown in that patent.

In the accompanying drawings, figure 1 represents a plan or top view of my improved apparatus; Fig. 2, a side elevation thereof; and Fig. 3, a vertical transverse section there through on the line 11 of Fig. 1.

In this instance, A represents a suitable base-board; B, B^1, B^2, B^3, B^4, suitable binding screws for the electrical connections; C, a triangular frame, upon which an electro-magnet, D, is mounted; E, E′, two ribbons or springs, provided with tension screws *e*, *e′*, by which they may be adjusted; and F, F′, two circuit-breaking springs, adapted to vibrate more slowly than the bars E, E′, and provided with mechanism to adjust their rate of vibration.

The ends of the magnets are provided with pole pieces *d*, *d'*, which extend opposite the springs, so that two or more of these springs or analyzing receivers may be included with the attraction of the same magnet.

When two notes of different pitch are transmitted through the electric circuit simultaneously, and the two receiving springs are tuned in unison with their respective transmitters, each will respond to its respective tone; but if either note is stopped, its corresponding receiver ceases to vibrate, just as if operated by a separate magnet, the reasons of which operation will be obvious upon consideration of the fact that the cores of all the magnets in the circuit respond to all the electric impulses sent through them, whether simple or complex, the analyzing principle being developed only by the appliances upon which the magnetic impulses act. From this it is obvious that one or more magnets would operate two or more tuned reeds or bars, mounted, in order to secure amplification of sound, upon resonant boxes, such as shown in my application for letters patent filed Jan. 8, 1876.

The advantages of this apparatus are not only in the direction of economy of saving in a number of magnets, but of battery-power, as it is well known that the induction of a great number of electro-magnets in a telegraph line seriously diminishes the working power of the battery.

In an application for letters patent, filed simultaneously herewith I have shown and described this apparatus, as carried out on a large scale, in combination with a printing telegraph.

I claim as of my own invention,—

The combination, substantially as hereinbefore set forth, in an electric circuit, of an electro-magnet through which notes of different pitch are transmitted with two or more vibrating receiving-springs, tuned correspondingly with the notes so transmitted, whereby each analyzer selects its own tone from the magnet without interfering with the others.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

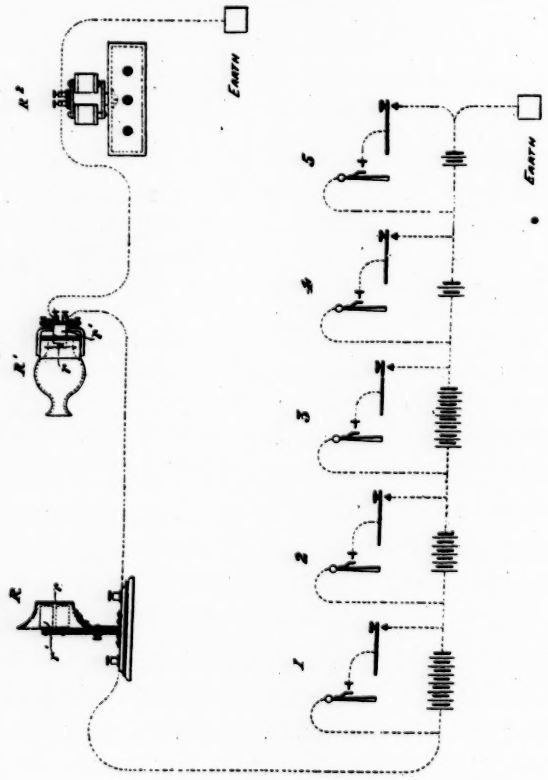
WM. A. SKINKLE,

W. J. PEYTON.

E. GRAY.

Art of Transmitting Rhythmical Vibrations in an Electric Circuit

No. 205,378. Patented June 25, 1878.



WITNESSES

Wm A Skinkle

Geo. H. Beach.

INVENTOR

Elisha Gray.

By his Attorneys

Baldwin Hopkins & Peyton

(No. 54g.) Defendants' Exhibit, "Gray's Common Receiver Patent."

J. A. W., Sp. Ex'r.

(Introduced in Record, p. 12.)

ELISHA GRAY, OF CHICAGO, ILLINOIS.

IMPROVEMENT IN THE ART OF TRANSMITTING RHYTHMICAL VIBRATIONS IN AN ELECTRIC CIRCUIT.

Specification forming part of Letters Patent, No. 205,378. Dated June 25, 1878. Application filed April 9, 1878.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois, have invented certain new and useful improvements in the art of generating and transmitting through an electric circuit rhythmical impulses, undulations, vibrations, or waves, representing composite tones, musical impressions or sounds of any character or quality whatever, and of audibly reproducing such vibrations, and also in apparatus for so generating, transmitting and reproducing such impulses, undulations, vibrations, or waves, of which improvements the following is a specification:

In Letters Patent of the United States Nos. 166,095 and 166,096, granted to me July 27, 1875, in the caveat filed by me February 14, 1876, and in sundry applications for Letters Patent for improvements in electric telephony filed October 29, 1877, I have shown devices intended to operate as common receivers and reproducers of all sorts of rhythmical vibrations representing sounds of whatever kind or quality with reference to the number of tones simultaneously transmitted, received and reproduced, and their relations to each other in respect to amplitude, rate, &c.

In an application for letters patent filed by me February 23, 1875, for improvements in the art of transmitting musical impressions or sounds telegraphically, and in apparatus for so transmitting such sounds, or impressions, I have shown devices for transmitting musical sounds and one method of arranging the same on an electric circuit to produce the desired results, including the relation of the main battery to the line and instruments at each end, and described the effects produced.

In Letters Patent No. 186,340, granted to me Jan. 16, 1877, I have shown and described a method of and apparatus for generating, transmitting, and reproducing in an electric circuit rhythmical impulses, undulations, vibrations or waves, as well as an improved method of connecting the transmitting apparatus to the line and main battery so that any tone of a series could be transmitted without interference with the power used for transmission of another tone and so that two or any greater number of tones could simultaneously be transmitted, received, and reproduced, preserving their individuality as perfectly as the same would be preserved in passing through the air. This patent also showed a closed circuit, in which a continuous current from a main battery kept a reproducing and receiving magnet constantly charged, and devices for varying the power or electro-motive force of the current by superposing thereupon the vibrations or undulations generated by the transmitter.

In Letters Patent No. 175,971, granted to me April 11, 1876f for improvements in telephonic telegraph apparatus, I have shown a series of receivers so constructed that each receiver which consists of a resonant box with a magnet having a tuned armature mounted upon it, will only respond to the particular note to which it is adapted, this apparatus, in practice, being arranged upon circuit as shown in my patent of Jan. 16, 1877, No. 186,340, above mentioned.

By having a number of receivers tuned to all rates of vibration, with correspondingly tuned transmitters, it is possible to transmit and receive composite sounds varying greatly in respect to quality, rate, &c. For instance the different vowel sounds may be transmitted and received by this apparatus, providing that the receivers are of the proper relation to each other, and all arranged near together, so as to get the composite effect of the tone sent through the wire.

Such an apparatus constitutes the subject matter of a division of this application, filed May 18, 1878.

To render the vowel sound A, for instance, I would transmit a composite tone, the simple elements of which would bear the following relations to each other. The amplitude of vibration of any simple tone which goes to make up the composition of a vowel or any sound is determined in this case by the number of cells of the battery used by the transmitter of that particular tone. Let us assume as a basis for the fundamental or lowest

tone in the clang or composition of tones one hundred vibrations per second. The vowel a is composed of five simple tones. If, as we have assumed, the first or fundamental tone have one hundred vibrations per second, the second tone will have two hundred, the third three hundred, the fourth four hundred, and the fifth five hundred. These tones, however, to produce the desired effect, must not all have the same amplitude or loudness; the second tone should be rather moderate in strength, which will be accomplished by giving it fewer cells of battery; the third, much greater amplitude, as this is the characteristic note of the clang, to accomplish which we add a greater number of cells of battery; while the fourth and fifth are added with a feeble amplitude. It will seem that by this arrangement we are able to control not only the number of tones transmitted but their relations with respect to rate and amplitude.

My present invention constitutes an improvement upon the invention set forth in the patents and applications above recited and contemplates the combination, in an apparatus for generating and transmitting vibrations, impulses, or waves representing composite tones of a closed circuit, a series of transmitters vibrating at such relative speeds to produce the fundamental and harmonics of the tone to be transmitted, a main battery so arranged as to give each transmitter the desired relative amplitude of vibration, and a common receiver, or one capable of reproducing tones of every variety and quality.

The subject-matter claimed will hereinafter specifically be designated.

The accompanying diagram represents an arrangement upon circuit of generating, transmitting and reproducing apparatus for carrying out my improvement, three different varieties of common receivers or reproducers being shown.

The different sections 1, 2, 3, 4, 5, of the main battery, it will be observed, are arranged, as to number of cells or electro-motive force, with respect to the amplitude of vibration or wave desired in each of the tones of the composition.

The diagram shows three different kinds of receivers R, R^1, R^2, each capable of reproducing composite tones or sounds of every character. It is deemed unnecessary to describe in detail the construction of the apparatus employed more than to say that it comprises main and local batteries, an apparatus for generating and transmitting vibrations representing the composite

tone to be transmitted, a receiving apparatus capable of reproducing such tones, and a closed circuit through which a continuous current flows to keep the magnets permanently charged. The arrangement of circuit is similar to that shown in my patent of Jan. 16, 1877, above mentioned, while the transmitters represented in the diagram are similar to those shown in Letters Patent No. 165,728, granted to me July 20, 1875. Each transmitter is operated by its respective local battery, omitted for convenience of representation. The receivers R, R^1, are similar to those shown in sundry applications for Letters Patent of the United States filed by me Oct. 29, 1877, and consist (speaking generally) of a diaphragm *r*, adjustably arranged relatively to an electro-magnet r^1. The receiver R^2 consists of an electro-magnet mounted upon a sounding box in a way that will be readily understood from the drawings, and (like the others) is capable of reproducing tones of all varieties and qualities.

It will be observed that my arrangement of batteries and transmitters admits of an unlimited variety of adaptations and combinations in respect to number and character of tones as to amplitude, rate, &c., so that when the quality of any tone is once determined by analysis it may be reproduced by my combination by the organization of the several parts relatively to each other.

The operation of my invention will be readily understood from the accompaying description, when it is desired to transmit a composite tone of a particular clang I depress the keys which bring into operation such batteries and transmitters as an analysis of such clang dictates we should use. To transmit a sound of different quality depress a different set of keys, arranged as before stated, with reference to the necessities of the case.

It is unnecessary to go into a detailed analysis of a great variety of sounds, as the principle involved is fully set forth in the case already given.

From the above it is easy to conceive that composite tones may be mechanically transmitted by a proper arrangement of transmitters, batteries, &c.

What I claim as of my own invention, and desire to secure by Letters Patent is

The combination, substantially as hereinbefore set forth in an apparatus for generating and transmitting vibrations, impulses, or waves representing composite tones, of a closed circuit, a series of transmitters vibrating at such relative speeds as to produce the

2479

fundamental and harmonics of the tone to be transmitted, a main battery so arranged as to give each transmitter the desired relative amplitude of vibration, and a common receiver, or one capable of reproducing tones of every variety and quality.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

GEORGE B. CUMMINGS,

D. M. ERSKINE, JR.

2450

(No. 54h). Defendants' Exhibit, "Gray's Revolving Drum Telephone Patent."

J. A. W., Sp. Ex'r.

(Introduced in Record, p. 12.)

ELISHA GRAY OF CHICAGO, ILLINOIS.

IMPROVEMENT IN SPEAKING TELEPHONE.

Specifications forming part of Letters Patent No. 210,776, dated December 10, 1878; application filed August 3, 1878.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook and State of Illinois, have invented certain new and useful improvements in speaking telephones, of which the following is a specification:

In Letters Patent No. 166,096, granted to me July 27, 1875, on an application originally filed April 18, 1874. I have shown and described apparatus for transmitting rhythmical vibrations representing composite sounds or musical tones of different pitch telegraphically, and for reproducing said tones at the receiving end of the line through the medium of animal tissue.

My present invention constitutes a new application of the principle exemplified in said letters patent, its object being to reproduce articulate sounds at the receiving end of the telegraphic circuit through animal tissue in gliding contact with a plate of suitable metal.

Any of the well known speaking telephones which transmit with sufficient intensity may be employed as a transmitter, in my improved apparatus I prefer, however, for a transmitter the one known as the "water telephone," described in a pending application for letters patent filed by me October 29, 1877, or the Edison carbon telephone transmitter, or some instrument used in connection with a battery, on account of the greater power which may be obtained from such a transmitter.

I prefer to use currents of considerable tension in working my improved apparatus, the most convenient and economical mode of

2431

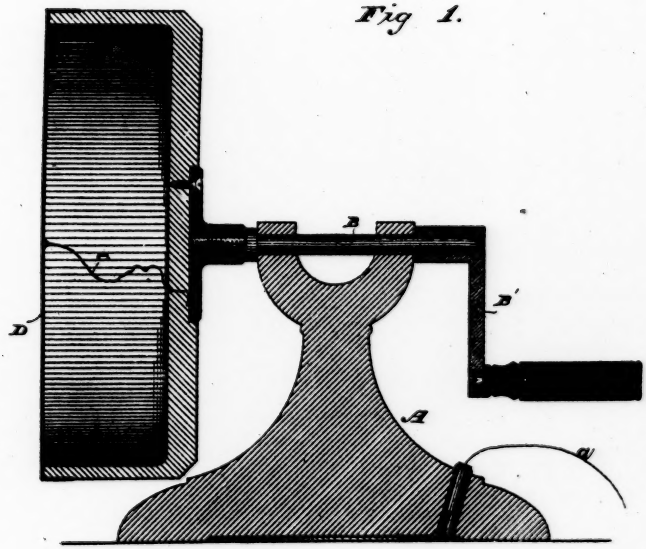
2 Sheets—Sheet 1.

E. GRAY.

Speaking-Telephone.

No. 210,776. Patented Dec. 10, 1878.

Fig 1.



WITNESSES

Geo W Breck

Wm A Stinkly

INVENTOR

Elisha Gray.

By his Attorneys

Baldwin, Hopkins & Peyton

2 Sheets—Sheet 2.

E. GRAY.

Speaking-Telephone.

No. 210,776. Patented Dec. 10, 1878.

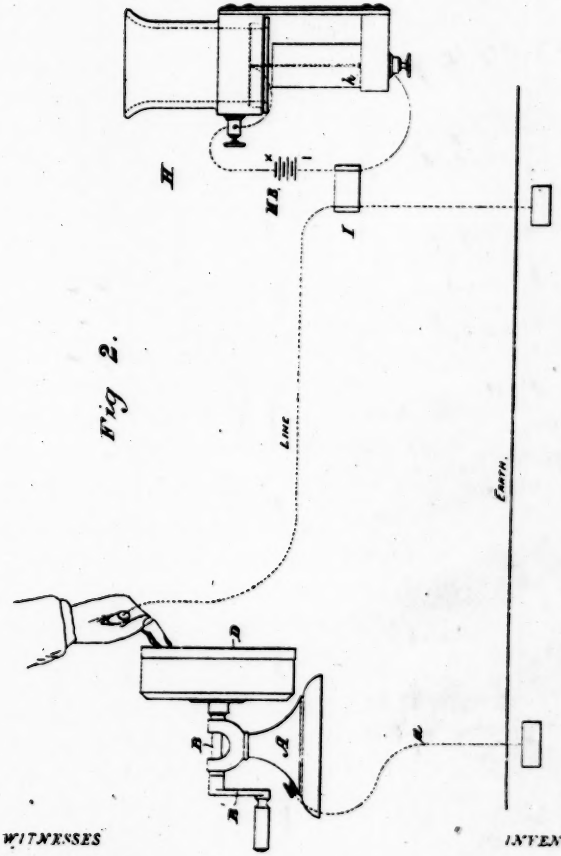


Fig 2.

WITNESSES

Wm A. Grindle

Geo H Buck

INVENTOR

Elisha Gray

By his Attorneys

Baldwin Hopkins & Peyton

doing which is by the use of an induction coil, as shown and described in my letters patent above-mentioned.

The receiving apparatus is substantially the same in construction and operation as the one heretofore employed by me for reproducing musical tones transmitted through a telegraphic circuit.

My invention therefore consists in combining in an electric circuit telephonic apparatus capable of transmitting articulate speech with a resonant receiver through the intervention of animal tissue in gliding or frictional contact with said resonant receiver. This receiver may consist of a plate of any of the well known metals, whether capable of induction or not. I prefer, however, to use a plate, disk or diaphragm of thin sheet metal, such as zinc or German silver, highly polished and oxidized on the surface exposed to friction. The friction or gliding contact between the animal tissue and the receiving plate may be produced in various ways, but I have found in practice the simplest and most effective to be to mount the receiving plate upon a resonant box or case mounted upon a shaft so as readily to be revolved by means of a pulley, crank, treadle or other well known motor. By this means an even pressure and uniform rotation of the receiving plate is secured.

The animal tissue may consist of one or more fingers of the human hand interposed in the circuit and pressed against the plate. Various other equivalent substances are mentioned in my patent above-mentioned.

The accompanying drawings show one convenient form of apparatus for carrying out the objects of my invention. Obviously, however, the details of construction of both the transmitter and receiver may be greatly varied without departing from the spirit of my invention.

Figure 1 represents an axial transverse section through the receiver; and Fig. 2 represents an arrangement upon circuit of the entire apparatus, including both transmitter and receiver.

The base or supporting stand A is, by preference, made of metal, and of a weight and size sufficient to maintain it in position without fastening it to its support. A shaft B revolves in suitable bearings upon this stand, being driven by a crank B′ or by a pulley, clockwork or other suitable prime mover, and carries a hollow resonant box or case of wood, or some other resonant substance, the outer or open end of this box is covered by a thin sheet metal disk, plate or diaphragm D, preferably of zinc, as the surface of this

2434

metal is usually covered with a very thin film of oxide, which is highly favorable to the proper action between the animal tissue and the plate when in gliding contact.

The diaphragm, it will be observed, is connected with a shaft and base by a wire *e*, inside the resonant box or case, the base being in turn connected with the ground by a wire *a*. The transmitter H in this instance is an ordinary speaking telephone of the form shown in my application filed October 29, 1877, above-mentioned, known as a "variable resistance telephone," which class includes the microphone, the carbon transmitter, the water transmitter and all others of that class which produce the sound waves by causing the vibrations of the diaphragm to vary the resistance of the battery current proportionately to the amplitude of motion of said diaphragm. I do not, however, confine myself to a transmitter of this class, but contemplate using any form which will transmit the vibrations with sufficient force.

The main battery, M, B, is shown in Fig. 2 as short circuited through the transmitter and through the induction coil I, having the usual primary and secondary circuits in such relation to each other as will produce the best results at the receiving end of the line.

Starting from the plus pole of the battery, the circuit passes through the transmitter point *h*, thence through the primary helix of the induction coil and back to the other pole of the battery. The secondary helix has one of its poles connected to the line, the other with the ground. At the receiving end of the line the circuit passes through animal tissue, which may consist of the human body or other equivalent material, which is in contact with the plate D, from whence the circuit passes through the ground through the stand, as shown in Fig. 2, and as hereinbefore described.

The induction coil may be dispensed with by using a battery of high tension and small quantity, but this method would not be so economical in practice as the one hereinbefore described.

In my patent of July 27, 1875, hereinbefore mentioned, I have shown that rhythmical vibrations in a primary circuit corresponding to any given musical tone, or any given number of tones simultaneously produced are correspondingly produced inductively in a secondary circuit, and that when these vibrations were passed through animal tissue in contact with a receiver such as described, the tones were audibly and accurately reproduced.

My present invention contemplates not only the production of

2435

musical tones, but sounds of every character and quality, so that any noise whether consisting of spoken words, musical tones or other sounds made or uttered in the transmitter or in its immediate vicinity, would be reproduced audibly at the receiving end of the line on the revolving plate.

I do not, therefore, claim the use of an animal tissue receiver for the reproduction of musical tones in combination with the transmitter only adapted to send such tones, as this constitutes the subject-matter of the patent hereinbefore mentioned.

What I claim herein as new and desire to secure by letters patent is,

The combination in a telegraphic circuit of a telephonic transmitter capable of transmitting articulate sounds or spoken words with a receiver capable of reproducing such sounds or words through the intervention of animal tissue in frictional contact with said receiver.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

JOHN F. PARET,

DAVID M. ERSKINE, JR.

(No. 54i.) Defendants' Exhibit, "Gray's Speaking Telephone Art Application."

[Introduced in Record, p. 12.]

(No. 54j.) Defendants' Exhibit, "Gray's Speaking Telephone Art Application."

J. A. W., Sp. Exr.

[Introduced in Record, p. 12.]

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, Greeting:

This is to certify that the annexed is a true copy from the files of this office of the file-wrapper, contents and drawing in the matter of the application of Elisha Gray, filed October 29th, 1877, for Art of Transmitting Vocal Sounds Telegraphically, &c.

In testimony whereof, I, Ellis Spear, Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this twenty-first day of August, in the year of our Lord one thousand eight hundred and seventy-eight, and of the independence of the United States the one hundred and third.

[L. S.]

ELLIS SPEAR,
Commissioner.

CASE 1. APPLICATION.

To the Commissioner of Patents:

Your petitioner prays that letters patent may be granted to him for the invention set forth in the annexed specification.

Also, that you will recognize Baldwin, Hopkins & Peyton, of Washington City, D. C., as his duly authorized attorneys, with full

2437

ELISHA GRAY.

3 SHEETS No 1

ART OF TRANSMITTING VOCAL SOUNDS TELEGRAPHICALLY

FILED OCTOBER 29TH 1877

Fig 1.

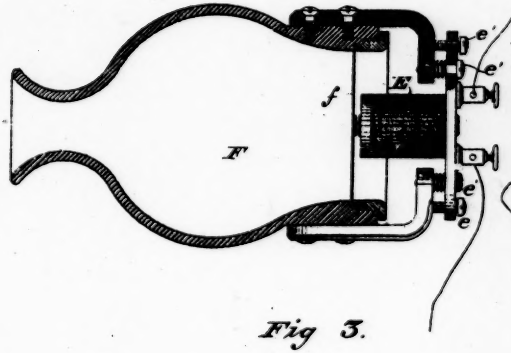


Fig 2

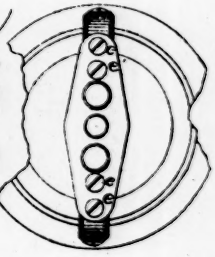
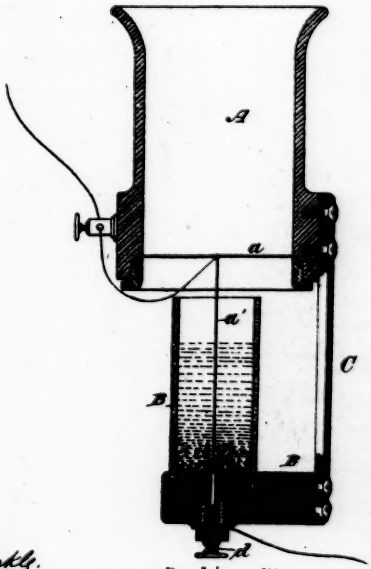


Fig 3.



WITNESSES

Wm A. Skinkle.

Geo W Breck.

INVENTOR

ELISHA GRAY.

By his Attorneys

Baldwin, Hopkins & Peyton

3 Sheets No 2

Elisha Gray

Art of Transmitting Vocal Sounds Telegraphically

2438

Filed October 29th 1877

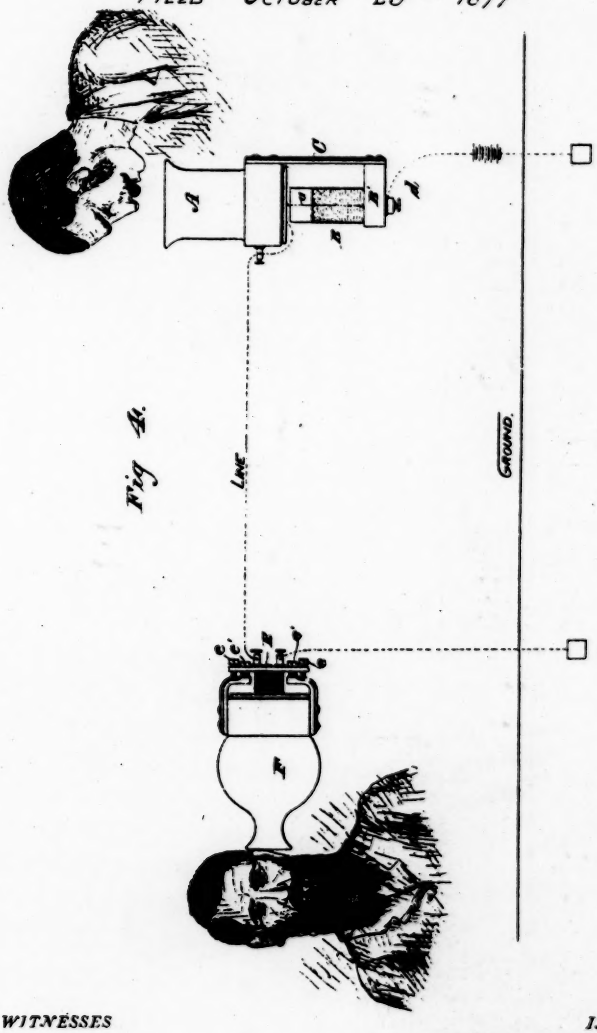


Fig 4.

WITNESSES

Wm A. Stinkly

Geo W. Breck.

INVENTOR

Elisha Gray

By his Attorneys

Baldwin Hopkins & Peyton

3 Sheets No 3

2439

ELISHA GRAY.

ART OF TRANSMITTING VOCAL SOUNDS TELEGRAPHICALLY

FILED OCTOBER 29TH 1877

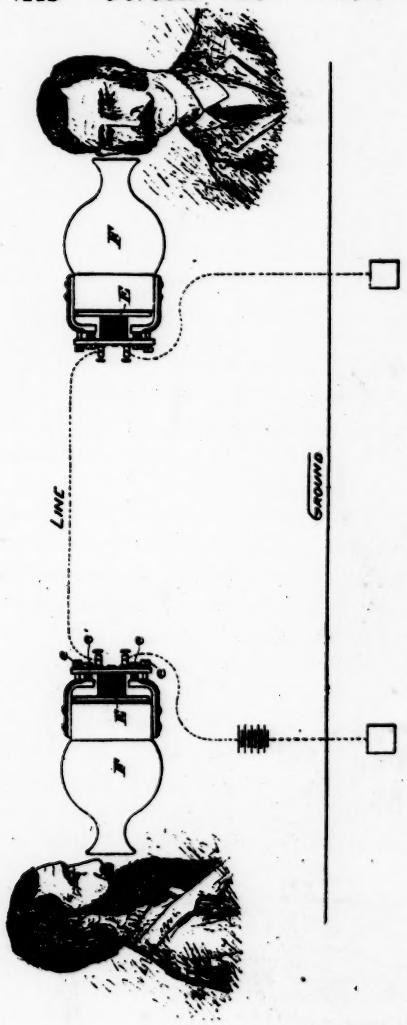


Fig 5.

WITNESSES

Wm. A. Skinkle.

Geo W. Buck

INVENTOR

ELISHA GRAY.

By his Attorneys.

Baldwin, Hopkins & Peyton

2140

power of substitution and revocation to prosecute this application, to make alterations and amendments therein, to receive the patent and transact all business in the Patent Office connected therewith.

ELISHA GRAY.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook, and State of Illinois, have invented a new and useful Art of Transmitting Vocal Sounds Telegraphically; as well as certain new and useful improvements on Apparatus for so Transmitting such sounds, of which art and apparatus the following is a specification:

The object of my invention is to transmit the tones of the human voice through a telegraphic circuit and reproduce them at the receiving end of the line, so that oral conversations can be carried on by persons at long distances apart.

I have heretofore invented and patented methods of transmitting musical impression or sounds telegraphically, and my present improvement is based upon a modification of the principle of said invention set forth and described in sundry letters patent, granted to me July 27, 1875, and respectively numbered 166,095 and 166,096; letters patent No. 173,460, granted to me February 15, 1876; and also in an application for letters patent of the United States, filed by me February 23, 1875.

To attain the objects of my invention I have devised an apparatus capable of vibrating responsively to all the tones of the human voice, and transmitting said vibrations through the electric circuit and reproducing them on a receiver correspondingly responsive to the tones of the human voice, and by which they rendered audible.

The subject matter claimed will hereinafter specifically be designated.

The accompanying drawings represent apparatus embodying my improvements in the best way known to me, but I contemplate various other applications and also changes in the details of construction of the apparatus, some of which obviously would suggest themselves to a skilled electrician, or to a person versed in the science of acoustics upon being made aware of my invention.

Figure 1 represents a vertical central section through one form

of an apparatus embodying my improvements capable of use either as a transmitter or as a receiver.

Figure 2 is an end view of a portion of the same.

Figure 3 represents a vertical transverse section through another form of transmitting apparatus, which forms the subject matter of another application for letters patent of the United States, filed by me simultaneously herewith.

Figure 4 represents a view of the apparatus arranged upon circuit to illustrate its operation more fully, showing a transmitter similar to that shown in figure 3 and a receiver similar to that shown in figure 1; and

Figure 5 shows an arrangement upon circuit similar to figure 4, with the exception that the transmitter and receiver are both like that shown in figure 1.

My present belief is that the most effective apparatus capable of responding to the various tones of the human voice consists of a tympanum or diaphragm combined with a frame or a chamber carrying apparatus for producing changes in the strength of an electric current.

The fundamental distinction between a diaphragm of the character contemplated by me and the one shown in the well-known Reis telephone is the absence of the contact point. Where such contact point is employed, the apparatus, while capable of transmitting musical tones, is incapable of transmitting articulate sounds or all the tones of the human voice; but when used as contemplated in the present case, not only musical tones, as before described, may be transmitted, but spoken words or other sounds of whatever character may be transmitted and reproduced at the receiving end of the line, so that ordinary conversations may be carried on over the circuit.

The transmitter shown in figure 3 consists of a box, chamber or tube A, by preference made with a flairing mouth. Across this chamber is arranged a diaphragm *a* of some thin substance such as parchment or gold-beater's skin, capable of responding to all the vibrations of the human voice, whether simple or complex. Attached to this diaphragm is a light metallic rod a^1, or other suitable conductor of electricity, which rod extends into the vessel B, of glass or other suitable insulating material, having its bottom closed by a plug, which may be of metal, or through which passes a conductor D, forming part of the circuit. The speaking tube A and base or stand B^1, which supports the vessel B, are held in a fixed

relation to each other by a suitable connecting frame C, or other well known means; and the conductor D, above mentioned, is mounted upon an adjusting screw *d*, by which means it may be adjusted very close to the rod a^1, without actual contact. The vibrations of the diaphragm *a* will thus cause the rod a^1 to vary its relation to the conductor *d*, thus varying the resistance and consequently the strength of the current passing through the circuit. It will be observed that the degree of variation in the strength of the electric current will correspond accurately with the amplitude and rapidity of the vibrations of the diaphragm, which vibrations, in the annunciation of any given word, are variable, both as to amplitude, rate and complexity.

The vessel B is filled with some liquid possessing high resistance to the electric current, such, for instance, as distilled water or other yielding substance possessing high resistance.

The transmitter must, of course, be mounted in a suitable frame to hold it securely and prevent the waste of the resisting medium where liquid is employed as such medium.

The variations in the strength of the electric circuit thus produced are transmitted to the receiving station or instrument, in which circuit is included an electro-magnet of ordinary construction acting upon a diaphragm preferably connected with a vocalizing chamber.

In figure 1 of the accompanying drawings a vocalizing chamber F is shown as provided with a diaphragm *f*, to which is attached a piece of soft iron f^1, constituting an armature in close proximity to the core of a magnet E, held in a fixed relation in regard to the vocalizing chamber by a suitable frame and provided with suitable adjusting screws *e* e^1, to adjust the magnet and diaphragm in proper relation to each other.

A sheet-metal diaphragm might obviously be substituted for the one just described. When a diaphragm of sheet iron or steel is used, the diaphragm itself constitutes an armature, and the piece of soft iron f^1, figure 1, may be dispensed with.

The proper proportion, form and mounting of this plate, disc or diaphragm are important conditions, which must be taken into consideration in order to obtain the best results.

The plate or membrane should be thin, preferably circular, equal in length and breadth, and should be rigidly supported at its edges in a proper frame, while the central portion, being elastic, is left

free to take up and respond to sonorous vibrations of every character.

All solid bodies tend to vibrate at a certain definite rate called the fundamental, and when shaped with reference to the development of this characteristic to the greatest extent, it is difficult to excite vibrations having any degree of amplitude other than the fundamental rate belonging to them respectively. A tuning fork is an example of a body whose form is calculated to develop this quality in a high degree. On the other hand, the more nearly a body assumes the form of a plate, preferably circular, made thin and supported not at one side alone, but all around its edges, the more it looses its special fundamental character and becomes capable of vibrating at one rate as readily as another. A plate or membrane in which this characteristic is developed in the greatest degree is best adapted to the transmission and reception of oral conversations.

Figure 4 shows the apparatus above described, arranged upon circuit, the operation of which will readily be understood from the foregoing description. The diaphragm of the transmitter A is thrown into vibrations by the voice of the operator, and the corresponding diaphragm at the receiving end of the line is thrown into corresponding vibrations with those of the transmitter, and audible sounds or words are produced.

Figure 5 shows two instruments similar to that shown in figure 1, arranged upon circuit to act both as receivers and transmitters, the operation being the same, although variations of the current strength are produced in the case of the transmitter first described by variation of resistance, while in the other case they are produced by the inductive action of the armature upon the fixed magnet.

By means of the apparatus thus described persons at a distance can converse with each other through an electric circuit and they now do in each other's presence.

What I claim as my invention and desire to secure by Letters Patent is:

1. The hereinbefore described art of transmitting and reproducing at a distance sonorous ways or vibrations of any description, which consists in increasing and decreasing the strength of an electric current traversing a circuit in such a manner as to produce in said circuit a series of electrical waves or vibrations precisely corresponding in their intervals of succession and relative ampli-

tudes to the sonorous waves which are to be reproduced at the receiving station or stations, so that oral conversations or sounds of any description whatever may be telegraphically transmitted.

2. The hereinbefore described improvement in the art of transmitting vocal sounds or spoken words telegraphically, which consists in throwing upon the line, through the medium of a varying resistance, electrical impulses corresponding to the vibrations of a diaphragm operated by the movements of the air, produced by a spoken word.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:
WM. D. BALDWIN,
WM. J. PEYTON.

CITY OF WASHINGTON, }
District of Columbia, } ss.:

ELISHA GRAY, the above-named petitioner, being duly sworn, deposes and says that he verily believes himself to be the original and first inventor of the art of transmitting vocal sounds telegraphically and apparatus therefor, described in the foregoing specification; that he does not know and does not believe that the same were ever before known or used, and that he is a citizen of the United States.

ELISHA GRAY.

Sworn to and subscribed before me this 20th day of October, 1877.

WM. J. PEYTON,
[L. S.] Notary Public.

2465

U. S.
Patent Office,
Oct. 29, 1877.

WASHINGTON, D. C., Oct. 29, 1877.

UNITED STATES PATENT OFFICE.

In the matter of the application of Elisha Gray for Letters Patent for Art of Transmitting Vocal Sounds Telegraphically, and Apparatus therefor, filed Oct. 29, 1877.

We request that a model may temporarily be dispensed with in the application above mentioned, and that the case be forwarded to the Examiner for his action.

The model will be filed in a few days.

Respectfully,
BALDWIN, HOPKINS & PEYTON,
Atty's for E. Gray.

To the Commissioner of Patents:

Model can be dispensed with for examination.

J. H. MCDONALD,
Ass't in Ch'g.

App'd.
W. H. DOOLITTLE,
A. C.

2446

U. S.
Patent Office
Oct. 29, 1877.

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1. REJECTION.

Oct. 31, 1877.

Room No. 118.
Case 1.
116–73.
Copy sent
Oct. 31, 1877.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Oct. 31, 1877.

Elisha Gray, care Baldwin, Hopkins & Peyton. Present.

Art of Transmitting Vocal Sounds Telegraphically.

Filed Oct. 29, 1877.

This application has been examined and found to be fully met by patent of A. G. Bell, Mar. 7, 1876, No. 174,465 (Elec-Telephonic Telh's). Magnet E is not described or shown as being in any manner different from the common form of electro-magnet consisting of a soft iron core, surrounded with coils of wire. Other characteristics are obviously necessary, in order to make the device operative.

On page 8 it is stated that the armature acts inductively; as this armature is stated to be of soft iron, this appears to be hardly correct. The application is accordingly refused.

H. C. TOWNSEND,
Ex'r.

2447

2. LETTER TO OFFICE.

Dec. 5, 1877.

WASHINGTON, D. C., Dec. 4, 1877.

To the Commissioner of Patents:

Sir—Herewith we file a model to complete the application of Elisha Gray, for Art of Transmitting Vocal Sounds Telegraphically, filed Oct. 29, '77.

Resp'y,
BALDWIN, HOPKINS & PEYTON,
Attys. for E. Gray.

U. S.
Patent Office,
Dec. 5, 1877.

---

3. LETTER TO OFFICE.

Dec. 8, 1867.

IN THE UNITED STATES PATENT OFFICE.

In the matter of the application of Elisha Gray, for Letters Patent for Art of Transmitting Vocal Sounds Telephonically, filed Oct. 29, 1877 (Case 1).

WASHINGTON, D. C., Dec. 8, 1877.

To the Commissioner of Patents:

Sir—We have the official letter of October 31, rejecting the above-mentioned application and request the prompt declaration of an interference with the reference cited, which, it will [be] observed by reference to the official records, was granted in derogation of Gray's caveat of even date, with the application upon which that patent was granted.

2448

The Office is mistaken as to its assumption of the inoperativeness of the "magnet E" described. Its practicability has been demonstrated by actual working. If an issue is made on this point, proof will be furnished. Moreover, we are unable to perceive why a soft iron armature will not act inductively. Our client, who is an electrician of twenty odd years' experience, knows of no such reason, and, on the contrary, has worked it as described in the specification. In fact, soft iron is one of the best-known substances for inductive action, being superior even to steel for this particular purpose.

Respectfully,

BALDWIN, HOPKINS & PEYTON,
Attorneys for E. Gray.

U. S.
Patent Office.
Dec. 8, 1877.

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4. INTERFERENCE A.

March 26, 1878.

Room No. 118. (No. 14.) (Interference.)

INTERFERENCE A.

116–73.
Copied.
Mar. 26, '78.

DEPARTMENT OF THE INTERIOR,
U. S. Patent Office,
WASHINGTON, D. C., Mar. 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present:

Please find below a copy of a communication from the Examiner concerning your application for patent for Art of Transmitting Vocal Sounds Telegraphically, filed Oct. 29, 1877.

(No. 1.)

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

2449

Your case above referred to is adjusted to interfere with the application and patents named below, and the question of priority will be determine1 in conformity with the rules accompanying this. The preliminary statement, demanded by Rule 53, must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it, endorsed on the envelope. The subject matter involved in the interference is: "The hereinbefore described art of transmitting and reproducing at a distance sonorous waves or vibrations of any description, which consists in increasing and decreasing the strength of an electric current, traversing a circuit in such a manner as to produce in said circuit a series of electrical waves or vibrations precisely corresponding in their intervals of succession and relative amplitudes to the sonorous waves, which are to be reproduced at the receiving station or stations, so that oral conversations or sounds of any description whatever may be telegraphically transmitted." (Gray's 1st Claim.)

This is substantially the method specified in Bell's fifth claim, and is described in the applications of Edison, Berliner, Richmond, Dolbear and Holcombe.

PARTIES TO INTERFERENCE.

Thomas A. Edison. App'n filed Apr. 27, 1877, (Case 130.) Atty. of record, L. W. Serrell, P. O. Box 4689, N. Y. City.

Emile Berliner. App'n filed June 4, 1877. Atty. of record, James L. Norris, Washington, D. C.

George B. Richmond. App'n filed Aug. 24, 1877. Atty. of record, George W. Dyer, Washington, D. C.

A. E. Dolbear. App'n filed Oct. 31, 1877. (A.) Attys. of record, Frank L. Pope, Elizabeth, N. J., James L. Norris, Asso. Atty., Washington, D. C.

A. G. Holcombe. App'n filed Jan. 28, 1878. Atty. of record, Moses G. Farmer, Torpedo Station, Newport, R. I.

A. G. Bell. Patent No. 174,465, dated Mar. 7, 1876. Atty. of record, A. Pollock, Washington, D. C.

H. C. TOWNSEND,
Ex'r.

2450

5. INTERFERENCE B.

Mar. 26, 1878.

Room No. 118. (No. 14.) (Interference.)

INTERFERENCE B.

116–73.
Copy.
Mar. 26, 1878.
P. W. P.

DEPARTMENT OF THE INTERIOR,
U. S. Patent Office,
WASHINGTON, D. C., March 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present:

Please find below a copy of a communication from the Examiner concerning your application filed Oct. 21, 1877, "Art of Transmitting Vocal Sounds Telegraphically."

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement, demanded by Rule 53, must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it, endorsed on the envelope. The subject matter involved in the interference is the hereinbefore described improvement in the art of transmitttng vocal sounds or spoken words telegraphically, which consists in throwing upon the line through the medium of a varying resistance electric impulses, corresponding to the vibrations of a diaphragm operated by the movements of the air produced by a spoken word. (Gray's 2d Claim.)

This is substantially covered in Bell's fourth claim, and is described in applications of Edison, Berliner and Richmond.

2451

THE PARTIES TO INTERFERENCE ARE

116

Elisha Gray, 73. Application filed Oct. 21, 1877. Attorneys of record, Baldwin, Hopkins & Peyton, Washington, D. C.

72

T. A. Edison, 64. App'n filed Ap'l 27, 1877. (Case 130.) Attorney, L. W. Serrell, Box 4689, N. Y. City.

86

Emile Berliner, 12. App'n filed June 4, '77. Attorney, Jas. L. Norris, Washington, D. C.

104

George B. Richmond, 58. App'n filed Aug. 24, '77. Attorney, Geo. W. Dyer, Washington, D. C.

158

A. G. Bell, 58. Patent No. 174,465, dated March 7, '76. Attorney, A. Pollok, Washington, D. C.

H. C. TOWNSEND,
Examiner.

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6. INTERFERENCE F.

Mch. 26, 1878.

Room No. 118. (No. 14.) (Interference.)

INTERFERENCE F.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., MARCH 26, 1878.

116–73.
Copy made
March 26, 1878.
H. C. T.

Elisha Gray, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your application, filed Oct. 29, 1877. "Art of Transmitting Vocal Sounds Telegraphically." (No. 1.)

Very respectfully,
ELLIS SPEAR,
Commissioner of Patents.

Your case above referred is adjudged to interfere with the applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it endorsed on the envelope. The subject matter involved in the interference is a telephonic transmitter, consisting of a coil of wire, one or more magnets, and a disc or diaphragm so arranged relative to each other, that a motion of the diaphragm shall induce in the coil of wire and electro-motive force in virtue of the presence of the magnet or magnets.

This is substantially Holcomb's first claim, and is described and shown in applications of Dolbear and Gray, and patent of Bell.

THE PARTIES TO THIS INTERFERENCE ARE:

A. G. Holcombe. Application filed Jan. 28, 1878. M. G. Farmer, Torpedo Station, Newport, R. I., Attorney.

A. E. Dolbear. App'n filed Oct. 31, '77. F. L. Pope, Elizabeth, N. J.; and J. L. Norris, Washington, D. C., Associate.

A. G. Bell. Patent No. 174,465, March 7, '76. A. Pollok, Washington, D. C., Attorney.

H. C. TOWNSEND,
Ex'r.

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7. INTERFERENCE H.

March 26, 1878.

Room No. 118. (No. 14.) (Interference.)

INTERFERENCE H.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., M'CH 26, 1878.

116-73.
Copy sent
March 26, 1878.
L. S. R.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner

concerning your app'n for patent for "Art of Transmitting Vocal Sounds Telegraphically" (Case No. 1), filed Oct. 29, 1877.

Very respectfully,

ELLIS SPEAR,

Commissioner of Patents.

Your case above referred to is adjudged to interfere with applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it endorsed on the envelope. The subject matter involved in the interference is: The combination in one circuit of two or more coils of wire, two or more magnets, and two or more discs or diaphragms so arranged relatively to each other, that if one of the discs or diaphragms be put in motion by the voice, by a current of air or otherwise, it shall induce a transient current of electricity in its associated coil, which current shall actuate the other discs or diaphragms in virtue of the coils and magnets associated with them. (Holcombe's third claim.)

This is described and shown in applications of Dolbear and Gray and Patent of Bell.

PARTIES TO INTERFERENCE.

A. G. Holcombe. App'n filed January 28, 1878. Moses G. Farmer, Torpedo Station, Newport, R. I., Att'y of Record.

A. E. Dolbear. App'n filed Oct. 31, 1877. F. L. Pope, Elizabeth, N. J., Att'y of Record. J. L. Norrsi, Asso. Att'y, Washington, D. C.

A. G. Bell. Patent No. 174,465, dated Mar. 7, 1876. A. Pollok, Washington, D. C., Att'y of Record.

H. C. TOWNSEND,

Ex'r.

R 454

INTERFERENCE I.

Room No. 118. March 26, 1878.

116–73. (No. 14.) (Interference).

Copy made
M'ch 28, '78.
L. S. R.

INTERFERENCE I.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, M'ch 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, present:

Please find below a copy of the communication from the Examiner, concerning your app'n for patent for "Art of Transmitting Vocal Sounds Telegraphically." (No. 1). Filed Oct. 29, 1877.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case, above referred to, is adjudged to interfere with applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement, demanded by Rule 53, must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it, endorsed on the envelope.

The subject matter involved in the intereference is: A telephonic transmitter, consisting of one or more helices, forming a portion of the main circuit and surrounding a core or cores, maintained in a magnetic state by the inductive influence either of an electric current or of a permanent magnet, in combination with an elastic inductive plate or armature, which is rigidly supported at one or more of its edges, while the portion facing the poles of the magnetic core or cores is left free, so as to be capable of responding to sonorous vibrations traversing the atmosphere or other bodies.

This is substantially Dolbear's 1st claim, and is substantially embraced in Bell's 3d and 8th claims. It is described in applications of Gray and Holcombe.

2455

PARTIES TO INTERFERENCE.

A. E. Dolbear. App'n filed Oct. 31, 1877. F. L. Pope, Elizabeth, N. J., att'y of record. J. L. Norris, Washington, D. C., Asso. Att'y.

A. G. Holcombe. App'n filed Jan. 28, 1878. Moses G. Farmer, Torpedo Station, Newport, R. I., Att'y of Record.

A. G. Bell. Patent No. 186,787, dated Jan. 30, 1877. A. Pollok, Washington, D. C., Att'y of Record.

H. C. TOWNSEND,
Ex'r.

1877.

Div. 16. Townsend. 116

73

No. No. 1.

Elisha Gray, of Chicago, County of Cook, State of Illinois.

Art of transmitting vocal sounds telegraphically, &c.

Rec'd,.....Oct. 29, 1877.
Petition,..... " " "
Affidavit,..... " " "
Specification,..... " " "
Drawing, 2 Sheets,..... " " "
Model,
Cert. Dep.,
1 Cash, $15,.....Oct. 29, 1877.
Add'l Fee Cert.,
" " Cash,
Examined,
2 Issue,
3 Patented,.....187 .
Circular,

BALDWIN, HOPKINS & PEYTON,
Present.

2456

1877.

CONTENTS.

Application, papers.

1. Rej., Oct. 31, 1877.
2. Letter to Office, Dec. 5, '77.
3. " " " " 8, "

72 86 104 118 135 158

A. 4. Int'f. x 64, 12, 58, 1, 90, 58, Mar. 26, 1878.

72 86 104 158

B. 5. Int'f. x 64, 12, 58, 58, Mar. 26, 1878.

135 118 158

F. 6. Int'f. x 90, 1, 58, Mar. 26, 1878.

135 118 158

H. 7. Int'f. x 90, 1, 58, Mar. 26, 1878.

118 135 42

I. 8. Int'f. x 1, 90, 26, Mar. 26, 1878.

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12.
13.
14.
15.
16.
17.
18.

TITLE:

Improvement in

Ex. M. McK.
M. V.

245

(No. 54k.) Defendants' Exhibit, "Gray's Liquid Transmitter Speaking Telephone Application."

J. A. W., Sp. Ex'r.

(Introduced in Record, page 12.)

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, Greeting:

This is to certify that the annexed is a true copy from the files of this office of the file-wrapper, contents and drawing, in the matter of the application of Elisha Gray, filed October 29, 1877, for apparatus for transmitting vocal sounds telegraphically.

In testimony whereof, I, W. H. Doolittle, Acting Commissioner of Patents, have caused the seal of the Patent Office to be hereunto affixed this [L. S.] twenty-ninth day of June, in the year of our Lord one thousand eight hundred and seventy-eight, and of the Independence of the United States the one hundred and second.

W. H. DOOLITTLE,
Acting Commissioner.

CASE 2—APPLICATION.

To the Commissioner of Patents:

Your petitioner prays that letters patent may be granted to him for the invention set forth in the annexed specification.

Also, that you will recognize Baldwin, Hopkins & Peyton, his duly authorized attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent Office connected therewith.

ELISHA GRAY.

2458

ELISHA GRAY

2 SHEETS Nº 1

APPARATUS FOR TRANSMITTING VOCAL SOUNDS TELEGRAPHICALLY

FILED OCTOBER 29TH 1877

Fig 1

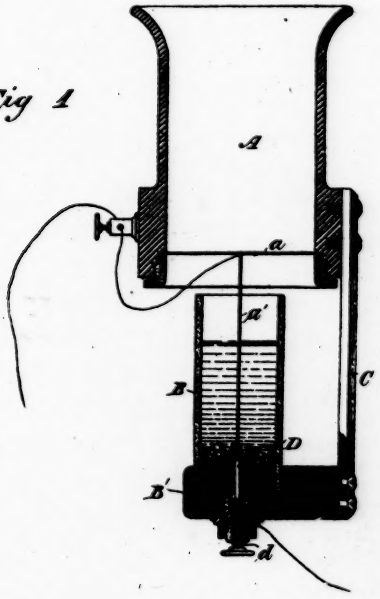


Fig 2.

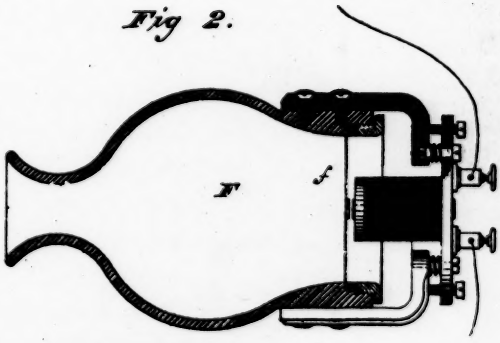
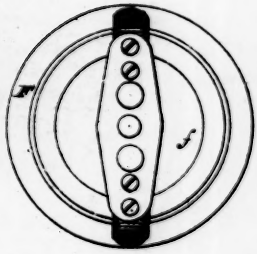


Fig 3.



WITNESSES

Wm A. Skinkle.

INVENTOR

Elisha Gray

By his Attorneys

Baldwin, Hopkins & Peyton.

2459

ELISHA GRAY. 2 SHEETS Nº 2

APPARATUS FOR TRANSMITTING VOCAL SOUNDS TELEGRAPHICALLY

FILED OCTOBER 29TH 1877

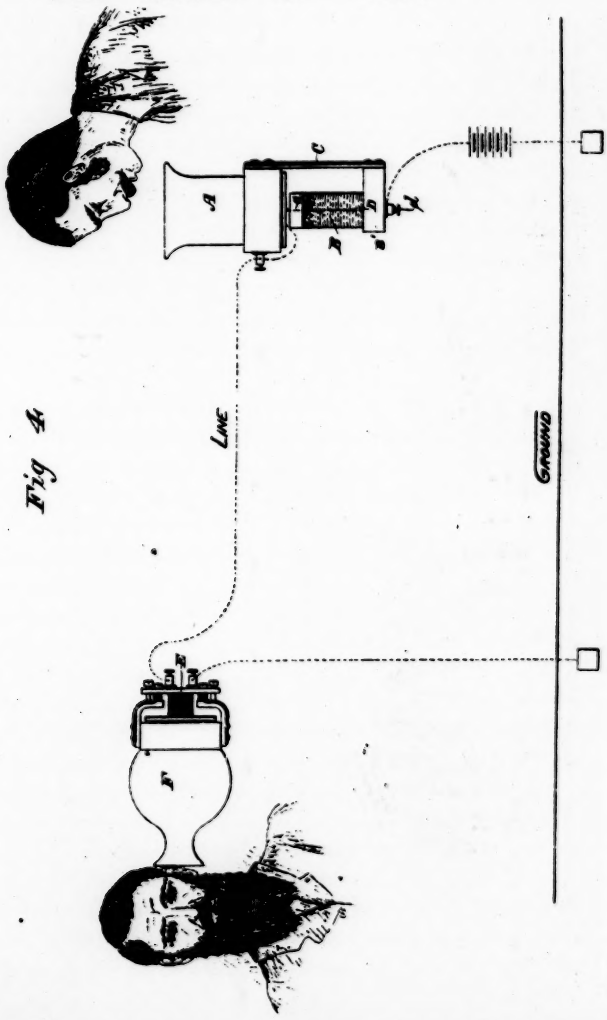


Fig 4

WITNESSES

Wm A. Stinkl.

INVENTOR

Elisha Gray

By his Attorneys

Baldwin, Hopkins & Peyton

To all whom it may concern:

Be it known, that I, Elisha Gray, of Chicago, in the County of Cook, and State of Illinois, have invented certain new and useful improvements in apparatus for transmitting vocal sounds telegraphically, of which the following is a specification.

The object of my invention is to transmit tones of the human voice through a telegraphic circuit, and reproduce them at the receiving end of the line, so that actual conversations can be carried on by persons at long distances apart.

My present invention more especially relates to that portion of the telephonic apparatus which takes up the vibrations of the air caused by the utterance of vocal sounds near it, and transmitting them through the circuit to the receiving end of the line, and my purpose is to adapt said apparatus to the accurate reproduction of such sounds as to tone, pitch and quality, which end I attain by interposing in the circuit a varying resistance which adapts itself to all the vibrations which are required to be transmitted through it.

In the accompanying drawings Fig. 1 represents a vertical transverse section through one form of an apparatus embodying my improvements.

Fig. 2 represents a similar section through a receiving apparatus of a different construction, but which is not herein claimed, as it constitutes the subject matter of another application for Letters Patent of the United States, filed by me simultaneously herewith.

Fig. 3 an end view of the same.

Fig. 4 represents the transmitter and receiver shown by the preceding figures, as arranged upon circuits.

The transmitter is by preference composed of a box chamber or tube A, provided with a flaring mouth, though the latter is not essential. Across this chamber is arranged a diaphragm *a* of some thin substance, such as parchment or gold beater's skin, capable of responding to all the vibrations of the human voice, whether simple or complex. Attached to this diaphragm is a light metal rod a^1, or other suitable conductor of electricity, which rod extends into a vessel B, of glass or other suitable insulating material, having its bottom closed by a plug, which may be of metal, or through which passes a conductor D, forming part of the circuit.

The speaking tube A, and base or standard B^1, which latter supports the vessel B, are held in a fixed relation to each other by a suitable connecting frame C, or other well known means, and the

conductor D, above mentioned, is mounted upon an adjusting screw *d*, by which means it may be adjusted very close to the rod, without actual contact. The same result, however, might be attained by adjustably connecting the tube A and standard B^1.

The vibrations of the diaphragm *a*, will thus cause the rod a^1 to vary its relation to the conductor D, thus varying the resistance, and consequently the strength of the current passing through the circuit.

It will be observed that the degree of variation in the strength of the electric current will correspond accurately with the amplitude and rapidity of the vibrations of the diaphragm, which vibrations in the annunciation of any given word are variable both as to amplitude, rate and complexity.

The transmitter must, of course, be mounted in a suitable frame, to hold it securely to prevent the waste of the resistance medium where liquid is employed as such medium.

The variations in the strength in the electric circuit thus caused are transmitted through the circuit to the receiving station or reproducing apparatus, in which circuit is included an electro-magnet E, of ordinary construction, acting upon a diaphragm *f*, in a vocalizing chamber F, the construction of which will be readily understood from the drawings.

Another form of reproducing apparatus is shown in an application for Letters Patent of the United States, filed by me simultaneously herewith.

What I claim as my invention, and desire to claim by letters patent is:

1. The transmitter hereinbefore described, consisting of the combination in an electric circuit, of a diaphragm and a liquid, or equivalent substance of high resistance, whereby the vibrations of the diaphragm, caused variations in the resistance of the electric circuit, and consequently in the strength of the current traversing said circuit.

2. The combination, substantially as hereinbefore set forth, in an electric circuit of a diaphragm, rese(r)voir containing liquid forming part of the circuit, a rod attached to the diaphragm and

projecting into the liquid, and an adjustable connection, whereby the paper relation between the parts of the circuit is maintained.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:
WM. J. PEYTON,
WM. D. BALDWIN.

DISTRICT OF COLUMBIA, City of Washington, } ss.:

ELISHA GRAY, the above-named petitioner, being duly sworn, deposes and says that he verily believes himself to be the original and first inventor of the Improvements in Apparatus for Transmitting Vocal Sounds Telegraphically, described in the foregoing specification; that he does not know and does not believe that the same was ever before known or used, and that he is a citizen of the United States.

ELISHA GRAY.

Sworn to and subscribed before me this 20th day of October, 1877.

[L. S.] WM. J PEYTON,
Notary Public.

United States,
Oct. 29, 1877,
Patent Office.

WASHINGTON, D. C., Oct. 29, 1877.
U. S. PATENT OFFICE.

"TRANSMITTER" (Case 2).

In the matter of the application of Elisha Gray, for Letters Patent for Apparatus for Transmitting Vocal Sounds Telegraphically, filed October 29, 1877.

We request that a model may be temporarily dispensed with in

the application above mentioned, and that the case be forwarded to the examiner for his action.

The model will be filed in a few days.

Respectfully,

BALDWIN, HOPKINS & PEYTON,
Attorneys for E. Gray.

To the Commissioner of Patents:

Model can be dispensed with for examination.

J. H. MCDONALD,
Assistant in Ch'g.

Approved:
W. H. DOOLITTLE,
A. C.

United States,
Oct. 29, 1877.
Patent Office.

1. REJECTION.

Oct. 31, 1877.

Room No. 118.
116–72.
Copy sent
Oct. 31, 1877.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., Oct. 31, 1877.

(Case 2.)

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

TELEPHONE OR SPEAKING TELEGRAPH.

Filed Oct. 29, 1877.

The 1st claim of this application is substantially met in Patent of A. G. Bell, Mar. 7, 1876, No. 174,465. (Elec. Telephonic Telp's.)

The first claim is accordingly refused.

H. C. TOWNSEND,
Exr.

2. LETTER TO OFFICE.

Dec. 4, 1877.

U. S. PATENT OFFICE.

In the matter of application of Elisha Gray, for Patent Apparatus for transmitting vocal sounds telegraphically. Filed Oct. 29, 1877.

WASHINGTON, D. C., Dec. 4, 1877.

To the Commissioner of Patents:

SIR—Herewith we file model to complete the above entitled application.

Resp.,
BALDWIN, HOPKINS & PEYTON,
Attys. for E. Gray.

Patent Office,
Dec. 4, 1877.
U. S. A.

LETTER TO OFFICE.

Dec. 8, 1877.

U. S. PATENT OFFICE.

In the matter of the application of Elisha Gray, for Letters Patent for Improvement in Telephonic or Speaking Telegraph. (Case 2). Filed October 29, 1877.

WASHINGTON, D. C., Dec. 8, 1877.

To the Commissioner of Patents:

SIR—The prompt declaration of an interference with the reference cited in the official letter of October 31, 1877, is requested, said patent being granted in derogation of Gray's caveat of even date with the application upon which it was granted.

Respectfully,
BALDWIN, HOPKINS & PEYTON.
Attorneys for E. Gray.

2465

Patent Office.
Dec. 8, 1877.
U. S. A.

4. INTERFERENCE C.

March 26, 1878.

Room No. 118 (No. 14). (Interference).

INTERFERENCE C.

116–72 (No. 2).
Copy sent
Mch. 26, 1878.
L. S. R.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., MAR. 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present:

Please find below a copy of a communication from the Examiner concerning your appln. filed Dec. 4, '77 (No. 2).

Very respectfully,
ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the patent and applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53, must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it endorsed on the envelope. The subject matter involved in the interterence is:

1st. The transmitter consisting of the combination in an electric circuit of a diaphragm and a liquid or equivalent substance of high resistance, whereby the vibrations of the diaphragm cause variations in the resistance of the electric circuit, and consequently in the strength of current traversing said circuit (Gray's 1st claim).

This is described in applications of Richmond and Edison and patent of Bell.

2d. In a telegraph instrument operated by sound, the combination with the diaphragm of two or more electrodes placed in electrolytic liquid, and operating to increase and decrease the resistance of the electric-circuit by the movement derived from the diaphragm (Edison's 1st claim).

This is described in the applications of Richmond and Gray, and is substantially suggested in Bell's patent.

The parties to this interference are: G. B. Richmond, application filed August 24, 1877; G. W. Dyer, attorney, Washington, D. C.; T. A. Edison, application filed September 5, 1877 (Case 144); L. W. Serrell, box 4,689, N. Y. City, attorney; A. G. Bell, Patent No. 174,465, March 7, 1876, A. Pollok, Washington, D. C., attorney.

H. C. TOWNSEND,
Exr.

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5. INTERFERENCE D.

March 26, 1878.

Room No. 118. (No. 14.) (Interference.)
116–72
Copy March 26, 1878.
P. W. P.

DEPARTMENT OF THE INTERIOR,
U. S. PATENT OFFICE,
WASHINGTON, D. C., MARCH 26, 1878.

INTERFERENCE D.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, present:

Please find below a copy of a communication from the Examiner concerning your appl'n for patent for "Apparatus for Transmitting Vocal Sounds Telegraphically" (Case No. 2) filed Dec. 4, 1877.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

2467

Your case above referred to is adjudged to interfere with applications named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it indorsed on the envelope. The subject matter involved in the interference is:

"In an electro-hydro telephone the fluid-holding vertically adjustable tube within which the ends of the platinum points are immersed, as set forth substantially in Richmond's 3d claim, described and shown in Edison's application and described in Gray.

PARTIES TO INTERFERFNCE.

George B. Richmond. Application filed August 24, 1877. George W. Dyer, Washington, D. C., Attorney of Record.

T. A. Edison. Application filed September 5, 1877. (Case 144.) L. W. Serrell, Box 4689, N. Y. City, Attorney of Record.

H. C. TOWNSEND,
Examiner.

1877.

Div. 16. Townsend. 116
72
No. (No. 2.)

Elisha Gray, of Chicago, County of Cook, State of Illinois,

Apparatus for Transmitting Vocal Sounds Telegraphically.

Received.....Oct. 29, 1877
Petition..... " " "
Affidavit..... " " "
Specification..... " " "
Drawing 2 Sheets..... " " "
Model.....Dec. 4, 1877
Cert. Dep.
1 Cash, $15.....Oct. 29, 1877
Add'l Fee Cert.
" " Cash.
2 Examined,

211468

Issue,
3 Patented, 187
Circular,

BALDWIN, HOPKINS & PEYTON,
Present.

1877.

CONTENTS.

		Application			paper.
	1.	Rej., Oct. 31st, 1877.			
	2.	Letter to Office, Dec. 4, 1877.			
	3.	"	"	" 8, "	
		104	107	158	
C.	4.	Intf. x 58,	15,	58,	Mar. 26, 1878.
		104	107		
D.	5.	Intf. x 58,	15,	Mar. 26, 1878.	
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	12.				
	13.				
	14.				
	15.				
	16.				
	17.				
	18.				

TITLE,

Improvement in
Exd. E. E. McC.
F. F,

2169

(No. 54m) Defendants' Exhibit, "Gray's Concave Diaphragm Receiver Speaking Telephone Application."

J. A. W., Sp. Ex'r.

(Introduced in Record, page 12.)

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, greeting:

This is to certify that the annexed is a true copy from the files of this office of the file-wrapper, contents and drawing, in the matter of the application of Elisha Gray, filed October 29th, 1877, for Electric Telephony.

In testimony whereof, I, Ellis Spear, Commissioner of of Patents, have caused the seal of the Patent Office to be hereunto affixed this twenty-first day of August, in the year of our Lord one thousand eight hundred and seventy-eight, and of the Independence of the United States the one hundred and third.

[L. S.]

ELLIS SPEAR,
Commissioner.

CASE 3.—APPLICATION.

To the Commissioner of Patents:

Your petitioner prays that Letters Patent may be granted to him for the invention set forth in the annexed specification.

Also that you will recognize Baldwin, Hopkins & Peyton, of Washington City, D. C., as his duly authorized attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the patent, and to transact all business in the Patent Office connected therewith.

ELISHA GRAY.

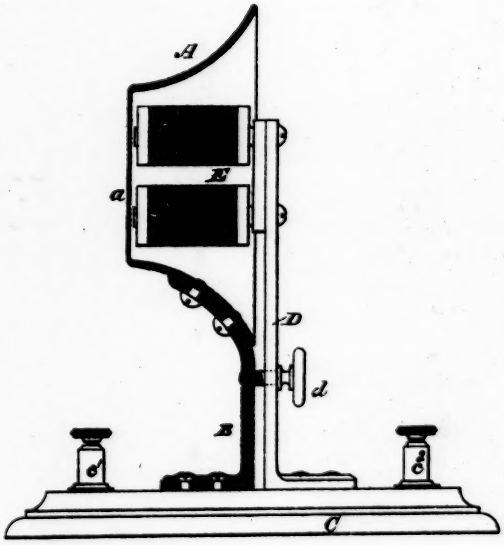
2170

ELISHA GRAY. 3 SHEETS Nº 1

IMPROVEMENTS IN ELECTRIC TELEPHONY.

FILED OCTOBER 29TH 1877

Fig 1



WITNESSES

Wm A Stinkle.

Geo W Beck.

INVENTOR

ELISHA GRAY.

By his Attorneys

Baldwin Hopkins & Peyton

7471

ELISHA GRAY

3 SHEETS Nº 2

IMPROVEMENTS IN ELECTRIC TELEPHONY.

FILED OCTOBER. 29TH 1877

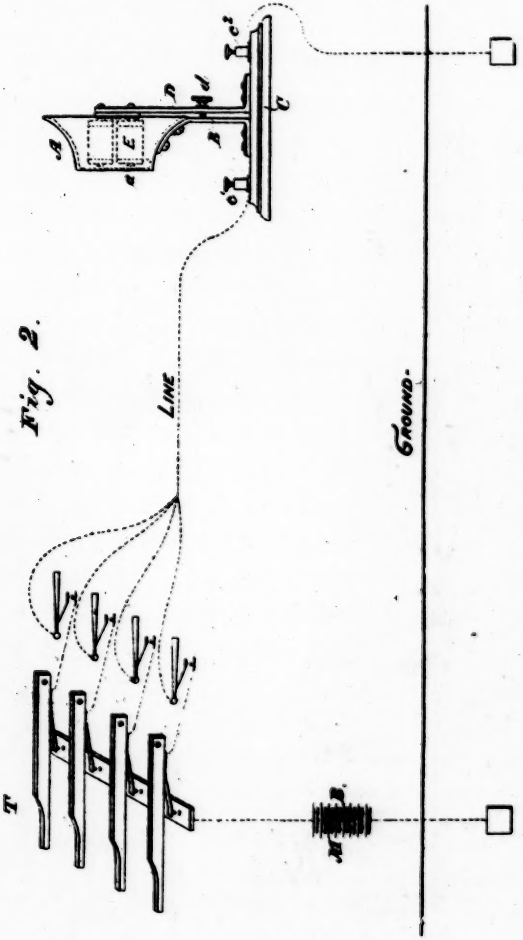


Fig. 2.

WITNESSES

Wm A Skinkle.

Geo W Breck.

INVENTOR

ELISHA GRAY

By his Attorneys.

Baldwin Hopkins & Peyton

11192

ELISHA GRAY.

3 SHEETS Nº 3

IMPROVEMENTS IN ELECTRIC TELEPHONY.

FILED OCTOBER 29TH 1877

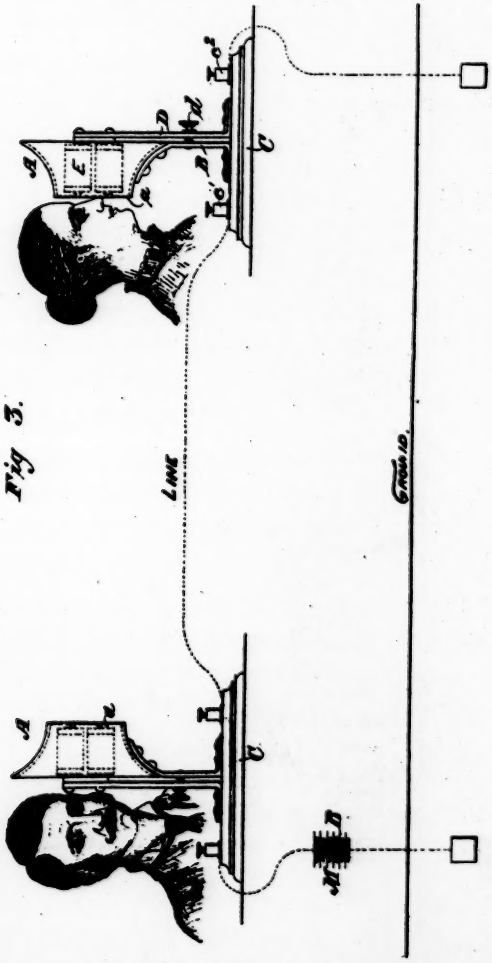


Fig 3.

WITNESSES

Wm. A. Skinkle.

Geo. W. Strock.

INVENTOR

ELISHA. GRAY.

By his Attorneys

Baldwin, Hopkins & Peyton

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook, and State of Illinois, have invented certain new and useful improvements in electric telephony, of which the following is a specification.

Letters Patent of the United States, granted to me on the 27th day of July, 1875, and respectively numbered 166,095 and 166,096, show a method of and apparatus for producing musical tones by the action of a series of vibrating electrotomes, whereby several musical notes simultaneously can be transmitted over a single electric circuit through a common receiver; and in an application for Letters Patent of the United States, filed by me February 23, 1875, I have shown and described an apparatus for analyzing tones thus transmitted at the receiving end of the line, there being a corresponding receiver for each transmitter.

The object of my present invention is to provide an apparatus capable of accurately reproducing in an electric circuit not only the different tones, but the pitch and quality of sounds, whether produced by mechanism or the vocal organs; to which ends my improvement consists, in interposing in an electric circuit an apparatus consisting essentially of a diaphragm arranged in close proximity to a magnet, so that the diaphragm is rendered sensitive to all electric impulses or vibrations transmitted through the circuit.

In the accompanying drawings.

Figure 1 represents a vertical central section through one form of my improved reproducing apparatus;

Figure 2 represents an arrangement of the apparatus upon circuit, showing a method of transmitting musicial tones produced by vibrating reeds or tuning-forks;

Figure 3 shows a duplicate arrangement of the reproducing apparatus in the circuit. In this figure either apparatus is capable of reproducing sounds transmitted from the other.

In this instance the reproducing apparatus is represented as consisting of a trumpet-mouth or basin shaped vessel, A, the bottom of which constitutes a diaphragm of thin sheet-metal, preferably of iron or steel. The vessel is secured by means of screws, or other well-known ways, upon a standard B, mounted upon a base or frame C, and electrically connected in well-known ways with the usual binding-posts, c^1, c^2. A post, D, also mounted upon this frame, supports a magnet E, the poles of which approximate closely the

diaphragm *a* of the vessel A. The relation of the poles of the magnet to the diaphragm is controlled by means of a set screw, *d*, connecting the posts B and D, or in other well-known ways.

In this instance the magnet is shown as arranged on the inner side of the reproducing vessel A, but it will be equally effective when arranged on the opposite side.

The proper proportion, form and mounting of this plate, disc or diaphragm are important conditions, which must be taken into consideration in order to obtain the best results.

The plate or membrane should be thin—preferably circular—equal in length and breadth, and should be rigidly supported at its edges in a proper frame, while the central portion, being elastic, is left free to take up and respond to sonorous vibrations of every character.

All solid bodies tend to vibrate at a certain definite rate, called the "fundimental," and when shaped with reference to the development of this characteristic to the greatest extent, it is difficult to excite vibration having any degree of amplitude other than the fundamental rate belonging to them respectively. A tuning-fork is an example of a body whose form is calculated to develop this quality in a high degree. On the other hand, the more nearly a body assumes the form of a plate, preferably circular, made thin and supported not at one side alone but all around its edges, the more it loses its special fundamental character and becomes capable of vibrating at one rate as readily as another.

The arrangement of the apparatus upon circuit is shown in figures 2 and 3, and is readily understood by reference thereto.

In Figure 2, M B represents the main battery, and T, a transmitting apparatus similar to that shown in Letters Patent No. 179,549, granted to me July 4, 1876, and shows a series of vibrating reeds, each transmitting a musical tone of different pitch, which may be thrown into operation simultaneously or successively by depressing the corresponding keys or levers, all the tones thus produced being transmitted over the line and reproduced by the receiving apparatus thus described.

Figure 3 shows the receiver and transmitter both alike.

With an apparatus thus constructed vocal sounds or articulate words spoken in one instrument will be accurately reproduced in the other, both as to pitch and quality, as well as tone; but I do not broadly claim in this application the transmission of vocal sounds telegraphically, as that forms the subject matter of another applica-

2475

tion for Letters Patent of the United States, filed by me simultaneously herewith.

It will be obvious to a skilfull electrician that the details of construction of the reproducing apparatus could be greatly varied without departing from the spirit of my invention, as long as it embodies the arrangement of a diaphragm vibrating in close proximity to but not in contact with a magnet.

What I claim as my invention and desire to secure by letters-patent is—

The combination, substantially as hereinbefore set forth, in an electric circuit, of a magnet and a diaphragm supported and arranged in close proximity thereto, whereby sounds thrown upon the line may be reproduced accurately as to tone, pitch and quality.

In testimony whereof, I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

WM. J. PEYTON,
WM. D. BALDWIN.

CITY OF WASHINGTON, } ss.;
District of Columbia. }

ELISHA GRAY, the above named petitioner, being duly sworn, deposes and says that he verily believes himself to be the original and first inventor of the Improvement in Electric Telephony, described in the foregoing specification; that he does not know and does not believe that the same was ever before known or used, and that he is a citizen of the United States.

ELISHA GRAY.

Sworn to and subscribed before me this 20th day of October, 1877.

WM. J. PEYTON,
[L. S.] Notary Public.

24/b

United States
Patent Office,
Oct. 29, 1877.

WASHINGTON, D. C., Oct. 29, 1877.

U. S. PATENT OFFICE.

"REPRODUCER." (Case 3).

In the matter of the application of Elisha Gray for letters patent for improvement in Electric Telephony, filed October 29, 1877.

We request that a model may temporarily be dispensed with in the application above mentioned, and that the case be forwarded to the Examiner for his action.

The model will be filed in a few days.

Respectfully,

BALDWIN, HOPKINS & PEYTON,
Attorneys for E. Gray.

To the Commissioner of Patents:

Model can be dispensed with for examination.

J. H. MCDONALD,
Assistant in Ch'g.

Appd.,
W. H. DOOLITTLE, A. C.

2477

United States
Patent Office,
Oct. 29, 1877.

1. REJECTION.

Oct. 31, 1877.

Room No. 118.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C., Oct. 31, 1877.

Copy sent Oct. 31, 1877.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, present:

Electric telephony. Filed Oct. 29, 1877.

The peculiarities of "magnet" F and its operation in connection with the diaphragm are not set forth with sufficient fullness. Said magnet is not described or shown as being in any manner different from the ordinary electro-magnet having soft iron core and surrounding coils.

The application, however, appears to be fully met in patent of A. G. Bell, January 30, 1877, No. 186,787 (Elec. Telephonic Tel'hs.) The application is accordingly refused.

H. C. TOWNSEND,
Examiner.

2. LETTER TO OFFICE.

Dec. 4, 1877.

U. S. PATENT OFFICE.

In the matter of the application of Elisha Gray for patent for electric telephony, filed Oct. 29, 1877.

WASHINGTON, D. C., Dec. 4, 1877.

To the Commissioner of Patents:

SIR—Herewith we file a model to complete the above-entitled application.

Respectfully,
BALDWIN, HOPKINS & PEYTON,
Attorneys for E. Gray.

United States
Patent Office,
Oct. 29, 1877.

WASHINGTON, D. C., Oct. 29, 1877.

U. S. PATENT OFFICE.

"REPRODUCER." (Case 3).

In the matter of the application of Elisha Gray for letters patent for improvement in Electric Telephony, filed October 29, 1877.

We request that a model may temporarily be dispensed with in the application above mentioned, and that the case be forwarded to the Examiner for his action.

The model will be filed in a few days.

Respectfully,

BALDWIN, HOPKINS & PEYTON,
Attorneys for E. Gray.

To the Commissioner of Patents:

Model can be dispensed with for examination.

J. H. MCDONALD,
Assistant in Ch'g.

Appd.,
W. H. DOOLITTLE, A. C.

2477

United States
Patent Office,
Oct. 29, 1877.

1. REJECTION.

Oct. 31, 1877.

Room No. 118.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C., Oct. 31, 1877.

Copy sent Oct. 31, 1877.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, present:

Electric telephony. Filed Oct. 29, 1877.

The peculiarities of "magnet" F and its operation in connection with the diaphragm are not set forth with sufficient fullness. Said magnet is not described or shown as being in any manner different from the ordinary electro-magnet having soft iron core and surrounding coils.

The application, however, appears to be fully met in patent of A. G. Bell, January 30, 1877, No. 186,787 (Elec. Telephonic Tel'hs.) The application is accordingly refused.

H. C. TOWNSEND,
Examiner.

2. LETTER TO OFFICE.

Dec. 4, 1877.

U. S. PATENT OFFICE.

In the matter of the application of Elisha Gray for patent for electric telephony, filed Oct. 29, 1877.

WASHINGTON, D. C., Dec. 4, 1877.

To the Commissioner of Patents:

SIR—Herewith we file a model to complete the above-entitled application.

Respectfully,
BALDWIN, HOPKINS & PEYTON,
Attorneys for E. Gray.

2478

: United States :
: Patent Office, :
: Dec. 4, 1877. :

---

3. LETTER TO OFFICE.

Dec. 8, 1877.

U. S. PATENT OFFICE.

In the matter of the application of Elisha Gray for letters patent for Electric Telephony, filed October 29, 1877. (Case 3.)

WASHINGTON, D. C., Dec. 8, 1877.

To the Commissioner of Patents:

SIR—We have the official Letter of October 31, 1877. An interference is requested with the reference cited, which patent was allowed and issued in direct violation of Gray's caveat, filed eleven months previously and in full force and effect when said patent was granted; and as the attention of the office had been specially called to this caveat at the time of the filing of the application for Bell's patent of March 7, 1876, we are at a loss to understand how it could have been so completely ignored by the office. By such action great injustice has been done to our client and his interests materially affected.

It being unnecessary for the purposes of this application that the construction and operation of the magnet with reference to the diaphragm should differ from its heretofore well known operation in connection with other forms of armature, it was deemed unnecessary to describe its operation more fully, as it is well known to all skillful electricians, but such explanation will be furnished if required.

The error of the office appears to have arisen from the assumption that an electro-magnet with a soft iron core would not act inductively.

The misapprehension may have been caused by over-looking the fact that Gray uses a battery and a closed circuit, consequently the magnet is permanently charged.

Respectfully,

BALDWIN, HOPKINS & PEYTON,
Attorneys for E. Gray.

2179

U. S.
Patent Office,
Dec. 8, 1877.

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4. (OFFICE) LETTER.

March 18, '78.

Copied March 18, 1878.
Room No. 118. Case No. 3.
116–71

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C., March 18, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Electric Telephony. Filed October 29, 1871.

On further consideration of this case with a view to the declaration of an interference involving patent of Bell and other pending applications, it appears that by inadvertence the patent of Bell, No. 186, 787, was cited in official letter of October 31, 1877, as an anticipation, when, in fact, the claim as drawn should have been rejected on reference to patent of Bell, No. 174, 465. It is true that applicant describes the diaphragm explicitly as a "metal" diaphragm but he also incidentally speaks of a "plate or membrane," so that by implication the diaphragm might possibly be said to be either of metal or some membraneous material with an armature attached, although such a construction is nowhere specifically described or shown.

In an application filed subsequently to the present it is explicitly stated that the diaphragm has an armature attached or that the diaphragm may itself be metallic and constitute the armature, and based on this description is a claim in the same terms as applicant's, which claim, viewed in the light of the specification, was necessarily rejected on the patent of Bell, No. 174,465. If the claim in the present application is to be construed so broadly as to include a membraneous diaphragm, it should obviously be also rejected upon Bell's patent No. 174,465; but if it is the intention to limit the application to a "metallic diaphragm," such limitation should be expressed in the claim by the use of the word metallic, and refer-

ence in the specification either specifically or impliedly to a "membraneous" diaphragm should be omitted.

As the matter now stands, the office is in doubt as to the exact scope of the specification and claim.

H. C. TOWNSEND, *Ex'r.*

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5. LETTER TO OFFICE.

Mar. 20, 1878.

UNITED STATES PATENT OFFICE.

In the matter of the application of Elisha Gray for Electric Telephony, filed October 29, 1877.

WASHINGTON, D. C., March 20, 1878.

To the Commissioner of Patents:

SIR—Referring to the official letter of the 18th inst., we request that Bell's patent No. 174,465, may be included in the Interference if there is anything in said patent relative to a Talking Telephone, as it is our client's intention to contest the matter in its broadest scope.

Respectfully,

BALDWIN, HOPKINS & PEYTON,

Att'ys for E. Gray.

2481

U. S.
Patent Office,
March 20, 1878.

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6. INTERFERENCE E.

M'ch 26, '78.

Room No. 118. (No. 14.) (Interference.)

116/71

(No. 3.) INTERFERENCE E.

Copy sent
Mar. 26, 1878.
L. S. R.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C., March 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present:

Please find below a copy of a communication from the Examiner concerning your application, filed Dec. 4, '77—Electric Telephony.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with the applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by Rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it endorsed on the envelope. The subject matter involved in the interference is in an acoustic telegraph, an armature plate, the electro-magnet for the same, and a closed circuit passing from the helix of such electro-magnet to the source of indulatory electric energy.

This is the subject-matter of Edison's 3d claim, and is substantially described in the other applications and the patent involved.

The parties to this interference are:

T. A. Edison, app'n filed Dec. 13, '77 (Case 145), L. W. Serrell, Box 4689, N. Y. City, Attorney.

A. E. Dolbear, app'n filed Oct. 31, '77, F. L. Pope, Elizabeth, N. J., Att'y of Record; Jas. L. Norris, of Washington, D. C., associate.

A. G. Holcombe, app'n filed Jan. 28, '78, M. G. Farmer, Torpedo Station, Newport, R. I., Att'y.

A. G. Bell, patent No. 174,465, March 7, '76, A. Pollok, Washington, D. C., Att'y.

Geo. B. Richmond, app'n filed Aug. 24, '77, G. W. Dyer, Washington, D. C., Att'y.

H. C. TOWNSEND, *Ex'r.*

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7. INTERFERENCE G.

M'ch 26, 1878.

Room No. 118. (No. 14.) (Interference.)

116–71 INTERFERENCE G.

Copy sent M'ch 26. L. S. R.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C., M'ch 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your app'n for patent for "Electric Telephony," filed Dec. 4, 1877 (Case No. 3).

Very respectfully,

Interference G. ELLIS SPEAR,
Commissioner of Patents.

Your case above referred to is adjudged to interfere with applications and patent named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing it endorsed on the envelope. The subject matter involved in the interference is "A telephonic receiver consisting of the combination in an electric circuit of a magnet and a diaphragm supported and arranged in close proximity

thereto, whereby sounds thrown upon the line may be reproduced accurately as to pitch and quality" (substantially Gray's claim).

This is substantially covered by Holcombe's 2d claim and is described or shown in the applications of Richmond Dolbear, Edison, and McDonough, and in patent of Bell.

Parties to Interference.

Elisha Gray, app'n filed Dec. 4, 1877 (No. 3), Baldwin, Hopkins & Peyton, Washington, D. C., Att'ys of Record.

Geo. B. Richmond, app'n filed Aug. 24, 1877, G. W. Dyer, Washington, D. C., Att'y of Record.

A. E. Dolbear, app'n filed Oct. 31, 1877, F. L. Pope, Elizabeth, N. J., Att'y of Record, J. L. Norris, Washington, D. C., Asso. Att'y.

T. A. Edison, app'n filed Dec. 24, 1877 (No. 148), L. W. Serrell, Box 4689, New York City, Att'y of Record.

A. G. Holcombe, app'n filed Jan'y 28, 1878, Moses G. Farmer, Torpedo Station, Newport, R. I., Att'y of Record.

James W. McDonough, app'n filed April 10, 1876, Gridley, Sherburne, Chicago, Ill., Att'ys of Record.

A. G. Bell, Patent No. 174,465, dated March 7, 1876, A. Pollock, Washington, D. C., Att'y of Record.

H. C. TOWNSEND, *Ex'r.*

---

8. INTERFERENCE J.

Mar. 26th, 1878.

Room No. 118. (No. 14.) (Interference.)

$\frac{1,1,6}{7,1}$ (No. 3.)

INTERFERENCE J.

Copy made M'ch 28, 1878.

DEPARTMENT OR THE INTERIOR,
UNITED STATES PATENT OFFICE,
WASHINGTON, D. C. March 26, 1878.

ELISHA GRAY, care Baldwin, Hopkins & Peyton, Present.

Please find below a copy of a communication from the Examiner concerning your application filed Dec. 4, '77—Electric Telephony.

Very respectfully,

ELLIS SPEAR,
Commissioner of Patents.

2484

Your case above referred to is adjudged to interfere with the applications and patents named below, and the question of priority will be determined in conformity with the rules accompanying this. The preliminary statement demanded by rule 53 must be sealed up and filed on or before the 6th day of May, 1878, with the subject of the invention and name of party filing endorsed on the envelope. The subject-matter involved in the interference is: The combination with an electro-magnet of an iron or steel diaphragm secured to a resonant case for rendering audible acoustic vibrations. (Edison's 1st Claim.) This is substantially embraced in Bell's 3d and Dolbear's 3d claims, and described in app'ns of the remaining parties.

The parties to this interference are:

T. A. Edison, app'n filed Dec. 24, '77 (Case 14)8, L. W. Serrell, Box 4689, N. Y. City, Attorney.

G. B. Richmond, app'n filed Aug. 24, '77, G. W. Dyer, Washington, D. C., Att'y.

A. E. Dolbear, app'n filed Oct. 31, 1877, F. L. Pope, Elizabeth, N. J., Att'y, and J. L. Norris, Washington, D. C., associate.

A. G. Holcombe, app'n filed Jan. 28, '78, M. G. Farmer, Torpedo Station, Newport, R. I., Att'y.

A. G. Bell, Patent No. 186,787, Jan. 30, '77, A. Pollok, Washington, D. C., Att'y.

H. C. TOWNSEND, *Ex'r.*

1877.

Div. 16. Townsend, 116

71

No. No. 3.

Elisha Gray, of Chicago, County of Cook, State of Illinois.

Electric Telephony.

Rec'd ..... Oct. 29, 1877
Petition ..... " " "
Affidavit ..... " " "
Specification ..... " " "
Drawing, 3 sheets ..... " " "
Model ..... Dec. 4, 1877
Cert. dep.

2485

1. Cash, $15.....Oct. 29, 187
   Add'l fee cert.
   " " cash.
2. Examined.
   Issue.
3. Patented.....187
   Circular.

BALDWIN, HOPKINS & PEYTON,
Present.

1877.

CONTENTS.

Application papers.

1. Rej., Oct. 31, 1877.
2. Letter to office, Dec. 4, '77.
3. Letter to office, Dec. 8, 1877.
4. Letter, ——, Mar. 18, 1878.
5. " to office, Mar. 20, 1878.

E." 6. Int'f. x $\frac{126}{48}$ $\frac{118}{11}$ $\frac{104}{58}$ $\frac{135}{90}$ $\frac{158}{58}$, Mar. 26, '78.

G. 7. Int'f. x $\frac{104}{58}$ $\frac{118}{1}$ $\frac{128}{58}$ $\frac{135}{90}$ $\frac{176}{32}$ $\frac{158}{58}$, Mar. 26, 1878.

J. 8. Int'f. x $\frac{128}{85}$ $\frac{104}{58}$ $\frac{118}{1}$ $\frac{135}{90}$ $\frac{42}{26}$, Mar. 26, 1878.

9.
10.
11.
12.
13.
14.
15.
16.
17.
18.

TITLE:

Improvement in

Ex. S. P. P.
M. McK.

36 Electricity.
Telephonic Telegraphs.

(No. 54p.) Includes the following Eleven Plate Exhibits introduced by Defendants from pp. 762 to 771 inclusive, and p. 773, of Dowd Record, Part II.

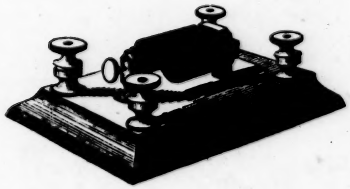
J. A. W., Sp. Ex'r.

[Introduced in Record, p. 12.]

437
2487

762

DEFENDANT'S EXHIBIT, GRAY'S FIRST SINGLE TONE TRANSMITTER.



DIMENSIONS.

Length of spool	$1\frac{1}{2}$ inches.
Diameter of spool	$\frac{3}{4}$ "
Length of core	$1\frac{7}{8}$ "
Diameter of core	$\frac{1}{4}$ "

2488

763

DEFENDANT'S EXHIBIT, ANIMAL TISSUE VIOLIN RECEIVER.

2489

DEFENDANT'S EXHIBIT, GRAY'S ANIMAL TISSUE REVOLVING PLATE RECEIVER.

DIMENSIONS.

Diameter of drum	$7\frac{1}{4}$	inches.
Thickness of drum	$2\frac{3}{8}$	"

2490

DEFENDANT'S EXHIBIT, PAPER DRUM RECEIVER.

DIMENSIONS.

Diameter of drum	3⅜ inches.
Thickness of "	1 "

2491

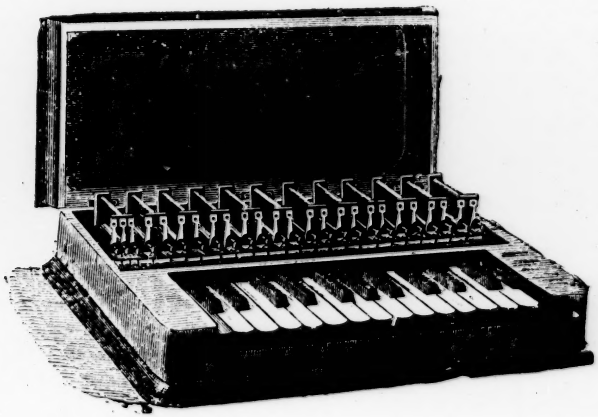
DEFENDANT'S EXHIBIT, GRAY'S CONCAVE METALLIC DIAPHRAGM MAGNET RECEIVER.

DIMENSIONS.

Diameter of concave diaphragm . . .	11 inches.
Diameter of base of diaphragm . . .	$5\frac{3}{4}$ "
Diameter of spool	$1\frac{3}{4}$ "
Diameter of core	$\frac{3}{8}$ "
Length of core	$3\frac{3}{8}$ "

249

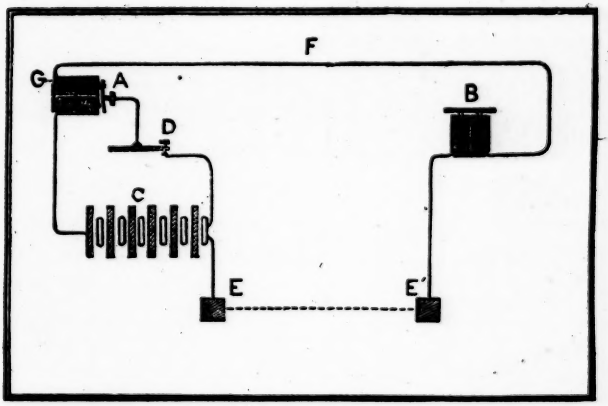
DEFENDANT'S EXHIBIT, GRAY'S TWO-OCTAVE TRANSMITTER.



2493

DEFENDANT'S EXHIBIT, GRAY'S CLOSED CIRCUIT SINGLE TONE TRANSMISSION APPARATUS.

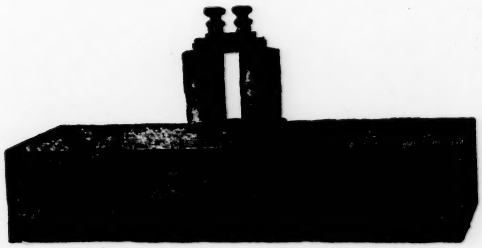
~~(RECORD, PAGE 85.)~~



A Single Tone Transmitter.
B Magnet Receiver.
C Battery.
D Key in Short Circuit.
E E' Ground Connection.
F Line Wire.

2494

DEFENDANT'S EXHIBIT, GRAY'S WOODEN SOUNDING BOX MAGNET RECEIVER.

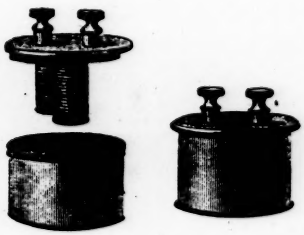


DIMENSIONS.

Length of box	16¼	inches.
Length of spool	2½	"
Diameter of spool	1¼	"

2495

DEFENDANT'S EXHIBIT, DIAPHRAGM BOX MAGNET RECEIVER.



DIMENSIONS.

Length of core	$1\frac{1}{2}$	inches.
Diameter of core	$\frac{1}{4}$	"
Diameter of cup	3	"
Height of cup	$2\frac{1}{8}$	"

2496

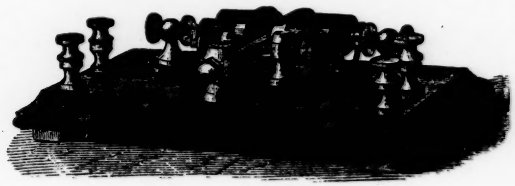
DEFENDANT'S EXHIBIT, GRAY'S MECHANICAL TRANSMITTER.

DIMENSIONS.

Length of shaft . . . . . $5\frac{1}{8}$ inches.

2497

DEFENDANT'S EXHIBIT, GRAY'S MULTIPLE TRANSMITTER OF 1875.



DIMENSIONS.

Length of spool	$1\frac{1}{2}$ inches.
Diameter of spool	$\frac{7}{8}$ "
Diameter of core	$\frac{1}{4}$ "
Length of core	$1\frac{5}{8}$ "
Length of reed	$3\frac{1}{4}$ "

2198

(No. 54q.) Defendants' Exhibit "Gray's Two-Tone Transmitter."

"This instrument is shown in various views in the drawings of "Defendants' Exhibit Johnson Patent, Gray's Magnetic Re-"ceiver."

(Introduced by defendants in Record, p. 12, from Dowd Record, p. 775.)

J. A. W., Sp. Ex'r.

(No. 54r.) Defendants' Exhibit "Tin-Plate Receiver."

"This is an ordinary tin plate about nine inches in diameter, "having a screw-cup attachment."

(Introduced by defendants in Record, p. 12, from Dowd Record, p. 775.)

J. A. W., Sp. Ex'r.

(No. 54s.) Defendants' Exhibit "Gray's Resonant Box Magnet Receiver."

"This is a hollow circular tin box with holes in the top, and is "about three and one-half inches in diameter and one inch in height. "It is shown, resting on the poles of an electro-magnet, on sheet 1 "of the drawings of Defendants' Exhibit Gray Magnet Receiver "Patent."

(Introduced by defendants in Record, p. 12, from Dowd Record, p. 775.)

J. A. W., Sp. Ex'r.

2499

(No. 55.) Defendants' Exhibit, McDonough Evidence.

J. A. W., Sp. Ex'r.

[Introduced in Record, page 12.]

MAY 14, 1884.

JAMES W. McDONOUGH, OF CHICAGO, ILLINOIS.

PENDING APPLICATION FILED APRIL 10, 1876. "TELELOGE."

To all whom it may concern:

Be it known that I, JAMES W. McDONOUGH, of the City of Chicago, in the County of Cook and State of Illinois, have invented a new and useful teleloge, and I do hereby declare the following to be a full, clear and exact description thereof, which will enable others, skilled in the art to which my invention appertains, to make and use the same, reference being had to the accompanying drawings forming part of this specification, in which

Fig. 1 represents a perspective view of a teleloge, embodying my said invention.

Fig. 2 represents a sectional plan of the same, taking on line *x x*, drawn across Fig. 1.

Fig. 3 represents a vertical transverse section of the teleloge taken on line *y y*, and

Fig. 4 represents a general plan or top view of the same.

Like letters of reference indicate like parts.

The object of my invention is to provide a means for transmitting articulate sounds from one place to another through the medium of electricity, and it consists in the combination with an electrical battery circuit wires, armature, magnet and circuit-breaker, of a transmitting and a receiving membrane or sounding apparatus, so constructed as to vibrate in accord with the vibrations of articulate sound, and so arranged relative to the magnet and circuit-breaker that the vibrations of the transmitting membrane or apparatus produced by articulate sounds, are transmitted by the electrical current to the receiving membrane or apparatus, and so as to cause a like vibration of the receiving membrane or apparatus, and it to reproduce the articulate sounds transmitted from and by the transmitting membrane or apparatus. My invention also con-

2500

J. W. Mc Donough,
Telegraph,
Filed Apr. 10. 1876.

Fig. 1

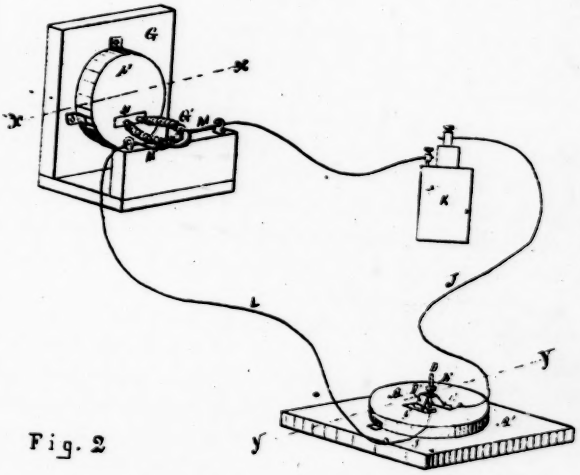


Fig. 2

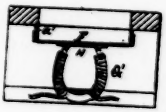


Fig. 3

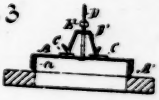
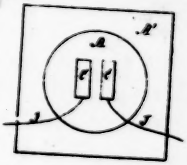


Fig. 4



WITNESSES:
Julius Wilcke
(illegible) Sherburne.

INVENTOR:
James W. McDonough
By Cudley & Sherburne
Attys

sists in the novel construction of the circuit-breaker, as is hereinafter more fully described.

In the drawing A represents the transmitting membrane or apparatus, composed of vellum, or any suitable material that is sensitive to the vibrations of sound, which is stretched upon a metal hoop or band *a*, permanently attached to the bed A′, and is so arranged upon the hoop or band as to admit of being tightened or looosened at will. C C are metal plates attached to the upper surface of the membrane A, at its center, and are insulated from each other. D is a metal bolt permanently attached at its lower end to said membrane A, centrally between the plates C C, and is insulated from them. D′ is the circuit-breaker, which consists of an arched shaped piece of metal loosely secured at its center upon the bolt D, and is bent upward at each end, and from the membrane A, as shown in Fig. 3, so as to form depending V-shaped points adapted to rest upon the respective plates C C. The circuit-breaker D′ is so fitted upon the bolt D as to admit of a free and easy ascending and descending movement, the limit of its ascending movement being determined by its contact with the nut E on the bolt, and the descending movement being limited by its contact with the plates C C. F is the receiving or sounding membrane, which is also composed of vellum or any suitable material that is sensitive to the vibration of sound, and is stretched upon a metal hook or band *a*′, secured to the side frame G, of the receiving or sounding apparatus, as shown in Fig. 1, and is so adjusted as to admit of being loosened or tightened as may be required.

G′ is the magnet surrounded by a helix of insulated wire, and connected to the instrument immediately in front of the membrane F; and at a point near its centre. H is the armature plate permanently attached to the membrane F, between it and the magnet, as shown in Fig. 1.

To each of the plates C C, is connected a wire J, one of which is connected with the battery K, and the other with the ground wire L. To each of the poles of the magnet is connected a wire M, one of which is connected with the battery K, and the other with the ground wire, as shown in Fig. 1.

The operation of my said teleloge is as follows: The transmitting membrane A, being sensitive to the vibrations of articulate sounds produced thereon, is caused to vibrate in sympathy therewith, thereby imparting an upward movement to the circuit-breaker at each vibration, and disconnecting it from the plates C C, and al-

ternately breaking and closing the circuit, when the intermittent current alternately magnetizes and demagnetizes the magnet G′, attracting the armature H, and causes it and the membrane F to vibrate simultaneously with the vibrations of the transmitting membrane A, and in accord therewith, and so that the said membrane F reproduces the articulate sounds transmitted from and by the membrane A.

I do not limit myself to the construction and arrangement of the circuit-breaker D′, as shown and described, as other means may be employed, as for example, only one of the plates C may be attached to the membrane, and the other made either in the form of a plate or needle and attached direct to the connecting wire, and adjusted to rest upon the plate so as to break the connection by the vibrations of the membrane which will accomplish the same result. It will be observed that each end of the circuit-breaker D′ is bent upward from the membrane, the object being to prevent local attraction and render its action more sensitive to the lighter vibrations of the membrane. The articulate sounds may be taken direct from the magnet, or through any substance or material sufficiently sensitive to the vibrations of sound to reproduce them by contact with the magnet.

Having thus described my invention, what I claim as new, and desire to secure by letters patent is:

"1. The combination with the battery, circuit wires, magnet, armature and circuit-breaker, of the transmitting membrane A, and receiving membrane F, substantially as and for the purpose specified.

"2. The combination with the plates C, C, of the circuit-breaker D′, whereby the circuit is alternately opened and closed by the vibrations of the membrane A, substantially as specified.

"3. The combination of the bolt D and adjusting nut E, of the circuit-breaker D′, substantially as and for the purpose specified."

JAMES W. MCDONOUGH.

Witnesses:

N. C. GRIDLEY,

N. H. SHERBURNE.

2503

The file contains the following:

U. S. PATENT OFFICE,
Room 118,
WASHINGTON, D. C., April 28, 1876.

J. W. MCDONOUGH,
Care Gridley & Sherburne, Chicago, Ill.:

"Teleloge,' April 10, 1876.

In this application the transmitter shown does not appear to differ substantially from that shown in the old Reiss telephone shown and illustrated in "Lerbuch der technischen Physik," Vienna, 1866, 3d edition. A view and description of such may be seen also in the "Scientific American" for March 4, 1876. An actual Reiss apparatus has also been in possession of the Smithsonian Institute, and on public exhibition there for some years.

Applicant's receiver seems to be substantially met in the patent of A. G. Bell, 174,465, March 7, 1876 (electricity; telephonic telegraphs).

On these references, applicant's claims are rejected.

Z. F. WILBUR,
Examiner.

To the Commissioner of Patents:

In the matter of the application of J. W. McDonough, for "Teleloge," filed April 10, 1876.

I hereby amend my specification as follows:

On 3d page strike out from and including the second line from bottom of said page to and including the tenth line on fourth page, and insert in lieu thereof the following, to wit:

"To the membrane A, or if this membrane be constructed of metal, it may be dispensed with, and the other either in the form of a plate or needle of any conducting material, and attached direct to the connecting wire and adjusted to rest upon the plate so as to break the connection by the vibration of the membrane, which in this case is controlled upon the same principle by the screw, and confined between two points for the purpose of receiving the finest vibrations and taking advantage of the pressure of the same upon the plate or point. The breaking of contract may be rendered more abrupt and the contact rendered more perfect by a drop of water or

2504

oil. The moisture of the atmosphere will accomplish the same result. The transmitting and receiving apparatus may both be connected to the same membrane at each end or station, and controlled by switches in the usual manner."

Strike out the several claims and insert in lieu thereof the following, to wit:

"The combination with membrane A, plates C, C, and circuit-breaker D', of the bolt D, and adjusting-nut E, for confining the vibrations of the membrane against the circuit-breaker, substantially as specified."

J. W. McDONOUGH,
By GRIDLEY & SHERBURNE,
Attorneys.

February 27th, 1878.
Filed March 4th, 1878.

UNITED STATES PATENT OFFICE, Room 118,
Washington, D. C., March 8, 1878.

JAMES W. McDONOUGH,
Care Gridley & Sherburne, Chicago, Ill.,

Speaking Telephone, filed April 10, 1876.

The amended claim filed in this case, March 4th, it is thought may be allowed. The matter introduced at the end of the specification by the amendment is, however, held to be new matter, as it describes modifications nowhere adverted to or shown in the application as originally filed.

This matter should consequently be erased.

H. C. TOWNSEND,
Examiner.

CERTIFIED COPY McDONOUGH'S LETTER TO THE COMMISSIONER OF PATENTS OF AUGUST 20, 1879, AND OF THE OFFICE REPLY. 2505

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, Greeting:

This is to certify that the annexed is a true copy from the files of this office of two letters, in the matter of the Interference of Holcomb vs. Gray vs. Dolbear, for Telegraphy.

In testimony whereof, I, E. M. MARBLE, Commissioner of Patents, have caused the seal of the Patent Office to be affixed this fourth day of May, in the year of our Lord, one thousand eight hundred and eighty-two, and of the Independence of the United States the one hundred and sixth.

[SEAL]

E. M. MARBLE.
Commissioner.

In the matter of the Interference between Holcombe, Gray, Bell, etc. vs. McDonough.

CHICAGO, August 20th, 1879.

The Hon. Com. Patents,
Washington, D. C.:

DEAR SIR—I have received a copy of the preliminary statement of Alexander Graham Bell, which seems to refer entirely to cases I, J. K., &c., Patent No. 186,787 and in no way pertaining to Patent No. 174,465 Interference G. Has not Mr. Bell made a separate statement in regard to Interference G? If so, will you please send to my address a copy of Mr. Bell's statement which refers to Interference G, in which I am concerned? I should like to ask a question, if not improper, having fully described in my application filed April 10th, 1876, a speaking telephone, am I not properly concerned in the case of Interference A?

By answer you will oblige

Yours truly,

JAMES W. MCDONOUGH.

290 So. Canal street,
Chicago, Ill.

2576

OFFICE LETTER TO McDONOUGH.

Room No. 3,
Copies sent.

DEPARTMENT OF THE INTERIOR,
UNITED STATES PATENT OFFICE,
Washington, D. C., Aug. 28th, 1879.

In Re-Interference

HOLCOMBE

vs.

GRAY vs. DOLBEAR, ET AL.

Before the Examiner of Interferences.

SUBJECT MATTER: "TELEGRAPHY."

JAMES W. McDONOUGH,
Care Gridley & Co.,
Chicago, Ill.

In answer to Mr. McDonough's letter dated August 20, 1879, he is informed that the judgment of the office was that he could not properly be a party in Case A. If he thinks that judgment wrong his proper remedy is to move (by regular motion) to be made a party thereto. His attention is called to Rules 119 and 120, a copy of which is this day mailed him.

Z. F. WILBUR,
Examiner of Interferences.

PRELIMINARY STATEMENT OF JAMES W. McDONOUGH.

Filed Sept. 23d, 1878.

UNITED STATES PATENT OFFICE,

BEFORE THE COMMISSIONER OF PATENTS.

In the matter of the interference between
Application of James W. McDonough, filed April 10, 1876.
And Letters Patent No. 174,465, dated March 7th, 1876, issued to A. G. Bell.
And application of Geo. B. Richmond, filed Aug. 24th, 1877.

2507

And application of A. E. Dolbear, filed Oct. 31st, 1877.
And application of Elisha Gray (No. 3), filed Dec. 4th, 1877.
And application of T. A. Edison (No. 148), filed Dec. 29th, 1877.
And application of A. G. Holcombe, filed Jan. 28th, 1878.
FOR TELEPHONE.

STATE OF ILLINOIS, }
County of Cook, } ss.:

JAMES W. MCDONOUGH, being duly sworn, deposes and says that he is one of the parties to the above-entitled interference; that he conceived the idea of a telephonic receiver, consisting of the combination of an electric circuit, of a magnet and a diaghragm, supported and arranged in close proximity thereto, whereby sounds thrown upon the line may be reproduced accurately as to pitch and quality; and also constructed a practical instrument as early as the 31st day of December, 1867; that subsequently, and on the 26th day of August, 1871, this deponent made drawings of a speaking telephone embodying his said ideas, and that thereafter, on the 30th day of June, 1875, this deponent reduced the same to practice by constructing and operating a speaking telephone substanially as shown and described in his said application.

JAMES W. MCDONOUGH.

Subscribed and sworn to before me this 25th day of September, A. D., 1878.

ARTHUR RYERSON,
[SEAL.] Notary Public.

Approved May 1st, 1879.

Z. F. WILBUR,
Examiner.

2528

UNITED STATES PATENT OFFICE,

BEFORE THE COMMISSIONER OF PATENTS.

In the Matter of Interference between

Eilsha Gray, A. E. Dolbear, A. G. Bell, Geo. B. Richmond, T. A. Edison, E. Berliner, and James W. McDonough.

FOR IMPROVEMENTS IN TELEPHONES.

You are hereby notified that on Thursday, the 20th day of January, A. D. 1881, at 10 o'clock, A. M., at the office of Gridley & Co., Room No. 7, No. 135 S. Clark street, in the City of Chicago, State of Illinois, we shall proceed to take testimony of James W. McDonough, Ada C. Eastman, John E. McDonough, Frank L. Eastman, Jeremiah E. Wilsey, T. B. Jeffery, Henry Greenwald, Calvin Cobb, Stephen Ryder, and L. M. Cobb, all of Chicago, Ill., and perhaps others, as witnesses in behalf of the said J. W. McDonough.

The examination wlll continue from day to day until completed. You are invited to attend and cross-examine.

Dated Chicago, January 10, 1881.

Yours, &c.,

GRIDLEY & Co.,
Attorneys for McDonough.

To BALDWIN, HOPKINS & PEYTON,
Attorneys for "Gray," No. 25 Grant Place, Washington, D.C.

To GEORGE W. DYER, ESQ.,
Attorney for "Richmond," No. 519 Seventh street, Washington, D. C.

To F. L. POPE, ESQ.,
Attorney for "Dolbear," 32 Park Place, New York City.

To L. W. SERRELL, ESQ.,
Attorney for "Edison," No. 140 Nassau street, New York City.

To J. J. STORROW, ESQ.,
Attorney for "Bell," and "Berliner," 40 State street, Boston, Mass.

2509

We hereby admit due service of a copy of the foregoing notice.

BALDWIN, HOPKINS & PEYTON,
Attorneys for Gray.

JAMES J. STORROW,
Counsel for Bell.

F. L. POPE,
Attorney for Dolbear,
By J. J. S.

Service acknowledged Jan. 15, 1881.

LEMUEL W. SERRELL,
Attorney for Edison,

WASHINGTON, D. C., January 15, 1881.

Good service this day upon me.

GEO. W. DYER,
Attorney of Record for Richmond.

UNITED STATES PATENT OFFICE.

In the matter of interference between Elisha Gray, George B. Richmond, A. E. Dolbear, T. A. Edison, A. G. Bell, E. Berliner and James W. McDonough for improvements in Telephones.

Depositions of witnesses examined on behalf of James W. McDonough, pursuant to the annexed notice at the office of Gridley & Co., No. 135 South Clark Street, City of Chicago, State of Illinois, on Thursday, January 20th, A. D., 1881 at 10 o'clock, A. M.

Present—N. C. GRIDLEY, ESQ., on behalf of James W. McDonough.

JAMES W. MCDONOUGH, being first duly sworn, does depose and say, in answer to interrogatories proposed to him by N. C. Gridley, Esq., counsel for the said James W. McDonough, as follows, viz.:

1st Question. What is your name, age, residence and occupation?

Answer. James W. McDonough; thirty-five years; residence,

2510

Chicago, Illinois; my occupation is that of a manufacturer, but I am not at the present time engaged in a regular business, having given up business some two years ago, on account of poor health.

On account of the non-arrival of foreign counsel engaged in this interference, on behalf of the several parties thereto, at the request of counsel for McDonough, I adjourn this examination until 2.30 o'clock, P. M., this 20th day of January, A. D., 1881.

FREDERICK A. HERRING,
Notary Public.

THURSDAY, January 20, A. D. 1881.
2.30 P. M.

EXAMINATION RESUMED—Present, N. C. GRIDLEY, ESQ., counsel for McDonough; J. J. STORROW, ESQ., counsel for Bell, and WILLIAM D. BALDWIN, ESQ., counsel for Gray.

F. A. HERRING,
Notary Public.

2d Q. Prior to giving up business, how long were you engaged in business, and in what kind of business?

A. I was in business for about fifteen years. I was manufacturer and wholesale dealer in bedding and upholstered parlor furniture. During this time I was a member of the firm of McDonough, Price & Co., and the firm was afterwards changed to McDonough, Wilsey & Co., which was the name of the firm at the time that I gave up business.

3d Q. Were you the head of the firms which you have mentioned, and did you have the principal charge in the management of the business of the said firms?

A. I was; I had the general management of the business and the general superintendence of the manufactories.

4th Q. Are you one of the parties to this interference?

A. I am.

5th Q. What has been your experience in relation to merchants and physicians and the construction of mechanical devices and patented inventions?

A. When I was about thirteen years of age I studied natural philosophy or physics in the High School at Cleveland, Ohio; we had there a good set of philosophical apparatus, consisting of tele-

graph instruments, galvanic batteries, acoustical apparatus, &c. I was very much interested in this study, and from that time to the present have made experiments with electrical apparatus and in chemistry and photography; previous to my entering in business for myself, I worked as a mechanic and am used to handling tools. I have taken out a number of patents for articles connected with the business I was engaged in.

I experimented in chemistry and with electrical apparatus whenever opportunity offered.

6th Q. Please state what was your experience in study and experiment, invention and practice, relating to the telegraphic transmission and reproduction of musical and vocal sounds or articulate speech; stating when you first conceived the idea of telegraphic transmission of sound and of articulate speech, and the reproduction thereof, giving in detail all your subsequent experiments, practice and the results produced?

A. In the year 1867 I lived with my folks in a house on Jefferson, between Madison and Monroe streets, in the City of Chicago; while there, I constructed an instrument for the purpose of converting an interrupted current of electricity into continuous sound. This instrument consisted of a magnet of wrought iron, covered or surrounded by a helix of insulated wire; the ends of the wire were left loose or free from the magnet about three feet. Before the magnet and supported by some books, in an upright position, was placed an iron hoop covered with a diaphragm of paper on the center of which was pasted a piece of tinned iron. The iron was placed close to the ends of the magnet, one of the loose ends of wire of the helix was connected with a galvanic battery, another wire connected the battery with a course file.

I operated this instrument by drawing the other loose end of the wire from the helix of the magnet over the file, thus making and breaking the current passing over the circuit, causing a magnetization and demagnetization of the magnet, thereby attracting the piece of iron fastened to the diaphragm, causing it to vibrate and produce sound.

7th Q. To what extent and what kind of sound was produced by the instrument you have described?

A. When the wire was drawn across the teeth, lengthwise of the file, a continuous sound was produced, the pitch varying with a rapidity of the motion.

8th Q. At what distance from the diaphragm could the sound or sounds be heard?

A. My ear was probably three feet from the diaphragm; the sounds were plainly audible at that distance.

9th Q. What time in the year 1867, month and day, was it that you constructed the instrument and produced the results you have spoken of?

A. I cannot tell that; I remember that it was in that house and in that year.

10th Q. In your preliminary statement you refer to this instrument and experiment as having been made and accomplished as early as the 31st day of December, A. D. 1867; why and how did you fix that date?

A. That is the last day of the year, and I know it was in that year and in that house.

11th Q. Have you the device or instrumentalities with which you made the experiments and produced the results which you have described now in your possession, or under your control? If not, what has become of the instrument or device?

A. I have a part of it; the iron ring and a part of the battery; the magnet I had in my possession until the year 1876; it was lost then. I don't know what became of the file. The diaphragm was of paper, and was destroyed in the course of time, and the tin lost. I took no particular care to preserve them; the wire I used in other experiments.

12th Q. Have you made, or caused to be made, under your direction and supervision, a drawing of the instrument with which you performed the experiment in 1867, and which you have described? If so, will you produce such drawing, to be attached to your deposition?

A. I have had one made under my supervision, and I hereby produce it.

Counsel for McDonough offer the said drawing in evidence, and the same is marked McDonough Drawing No. 1. F. A. Herring, Notary Public.

13th Q. Who composed the members of the family with whom you resided in the year 1867, in the Jefferson street house, at the time you made the instrument and the experiment you have de-

2513

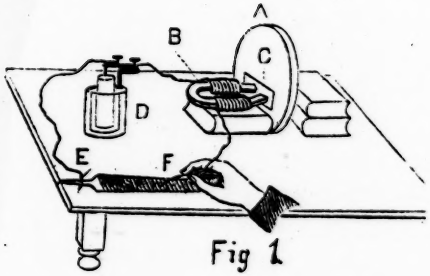


Fig 1

RECEIVER.

A Iron Hoop covered with Paper Diaphragm.
B Iron Magnet with Helix.
C Iron Plate fastened to Diaphragm.
D Battery.
E Wire connecting Battery and File.
F Wire connecting Magnet and File.

F. A. HERRING.
Notary Public.

2514

scribed; and who, if any of them, had knowledge of the construction of the instrument, and of your experiments?

A. My step-father, Jeremiah E. Wilsey; my mother, Margaret V. Wilsey; John E. McDonough and Ada C. Wilsey, now Ada C. Eastman, and myself; they all knew that I was making experiments with electrical instruments. Mr. Wilsey knew the object of my experimenting; my mother is dead.

14th Q. State what you next did toward the development of the invention which is the subject matter of this interference, when and where, and under what circumstances, and particularly when you first conceived the idea of a speaking telephone?

A. I was in the habit of making memoranda and sketches of ideas that occurred to me, for the purpose of preserving them and calling them to my mind, and I find a memorandum sketch in a book that I used for that purpose, dated August 26th, 1871.

JANUARY 20, 1881, 4.15 P. M.

Examination adjourned until 9.30, A. D. January 21, 1881, at the same place.

F. A. HERRING,
Notary Public.

FRIDAY, JANUARY 21, A. D. 1881, 9.30 A. M.

EXAMINATION RESUMED.

Present—N. C. GRIDLEY, ESQ., Counsel for McDonough; J. J. STORROW, ESQ., Counsel for Bell; and WM. D. BALDWIN, ESQ., Counsel for Gray.

F. A. HERRING,
Notary Public.

Witness resumes answer to 14th question, as follows, viz.:

This sketch followed my conception of a speaking telephone, and was a memorandum or a sketch of several methods of making an instrument when I should find an opportunity to work at it. At this time I had read accounts and descriptions of the phonautograph,

an instrument for recording vibrations produced by the sound of the human voice in a diaphragm and recorded or written on a blackened surface. I had also read a brief description of the Reiss telephone, but had seen no illustration of it. I was acquainted generally with the state of acoustical science at that time. While making some drawings in reference to an electrical motor I conceived of the idea of an instrument which would convey articulate sounds through the means of electricity and reproduce them at a distance. Part of this plan was the employment of a diaphragm or membrane at each station.

15th Q. Have you in your possession the book containing the sketch to which you refer, dated August 26th, 1871, and if so, will you produce such book, refer to such sketch or sketches, and give a description thereof, as to what they were intended to illustrate?

A. I have the book and produce it, and show the leaf containing the sketch. The drawings show one receiver, consisting of a stretched membrane, on which is pasted a piece of metal, and before which is an electro-magnet, which is connected with a battery and with a transmitter, consisting of a membrane stretched over a hoop, in the center of which membrane or diaphragm is fastened a small piece of metal, connected by wire with a magnet of the receiver. Upon this small piece of metal rested a piece of metal in the shape of a pin, which was supported by a frame. This metal pin was connected by wire with the battery, thus completing the circuit. The other sketches were of different plans of a transmitter that suggested themselves to me as possible ways of constructing a transmitter. There is attached to the sketch the writing, "August 26, 1871. To send speech through wires by means of electricity."

16th Q. When was the memorandum, to which you refer, made, and by whom?

A. It was made on the 26th day of August, 1871, and by myself.

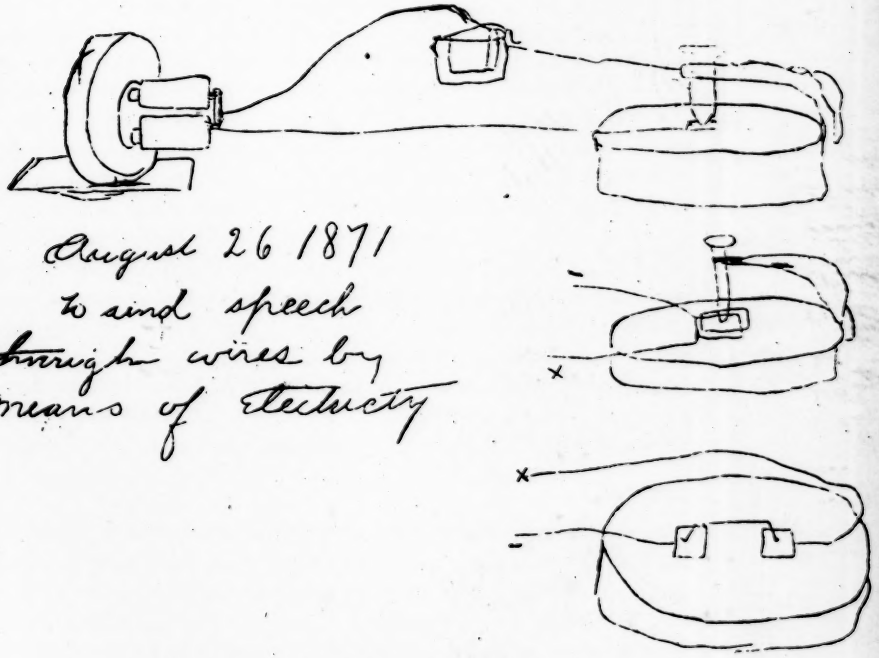
17th Q. What use have you made of the book in which this sketch and memoranda are contained?

A. The book was bought for use in our manufacturing business, and contained a list of names of dealers in furniture. This list filled but a small portion of the book, and when it was out of date I cut the leaves out containing those names and used the book for a scrap book. It contained some accounts and other matter, and sketches and memoranda of over thirty (30) different ideas and conceptions.

I afterwards, in 1876 or 1877, copied what I thought worth preserving into another book and threw this aside as of no value.

2576

McDONOUGH DRAWING OF AUGUST 26, 1871.



Fac simile of Drawing made August 26, 1871.

F. A. HERRING,
Notary Public.

18th Q. Please mention for what purpose some of the several sketches, drawings, or memoranda to which you referred in that book were made?

A. What is called a ball-caster is one. Another was an electro-motor—half a dozen sketches of it. A cartridge box, an envelope counter, another electro-motor, a machine for making wire staples, memoranda concerning photographs in natural colors, some ideas on electric light, a fire extinguisher, to produce action in artificial limbs by action of electricity controlled by raising the muscles in stump; and a lot of more things.

19th Q. Were the sketches, drawings, or memoranda to which you have referred all made by you? And were they placed or made in said book in regular order of date, or time, or how otherwise?

A. All that I have referred to were made by me; there was no attempt made at system in any part of the book. I made the drawings or memoranda wherever I happened to open the book or to find any vacant space.

20th Q. State whether or not the drawings and memoranda made by you or your conception of the speaking telephone or transmitter and receiver, to which you have referred as having been made August 26, 1871, are now in the same condition as you then made them, and whether or not you have, at any time, altered or changed them in any particular?

A. They are in the same condition; I have made no alterations in them.

Counsel for McDonough offers the book referred to in evidence, and the page containing the drawings is marked "McDonough Drawing of August 26, 1871." F. A. Herring, Notary Public.

By consent of counsel, a facsimile, referred to of August 26, 1871, is attached to this deposition. The book referred to is to remain in the custody of the witness and is to be produced on the hearing if required by counsel.

21st Q. When was your attention again called to the subject of speaking telephones, and what did you next do, and when and where, towards the development of your conception of the speaking telephone?

A. In April of the year 1874 I resided at No. 584 West Washington street, Chicago. At this time my attention was again called

2578

to the subject of electrical transmission of articulate sounds, and I started to work upon an instrument for the accomplishment of that purpose. I put my batteries into shape, and had made a magnet of wrought iron at the centre or base of which was soldered a screw for the purpose of fastening the magnet to a frame. I made no further progress on account of ill-health. I made preparations and went to Europe for the benefit of my health, starting about the middle of May, 1874. I returned to Chicago in November, 1874. While I was absent the firm of which I was a member commenced the erection of the building 290 to 294 South Canal street, Chicago, to use as a manufactory. I had to break myself into business from which I had absented myself, and give extra attention to building, and had no time to experiment.

22d Q. What was the condition of your health, bodily and mentally, prior to your departure for Europe in May, 1874, and how long previous to that time had you been in ill-health?

A. I never had perfect health, and at times was incapacitated for work of any kind; previous to my departure for Europe I spent a good portion of the day lying on my back, and at last was compelled to take a vacation; I was incapable of doing any kind of work, either mental or physical.

23d Q. What causes, if any, existed between the conception of your idea of the telephone for the purpose of transmitting articulate words, and the date of your departure to Europe, which prevented you from developing your idea and reducing it to practice?

A. Attention to business; after the fire of 1871 we moved our place of business, and moved into smaller quarters; our business increased, and general ill-health, which did not permit me to give a great deal of time to outside matters; I had a great many ideas and conceptions that I never had an opportunity to work upon.

24th Q. Please state what you next did, when and where and under what circumstances, towards the development of your idea of the speaking telephone, stating any circumstances that were an incentive to you to proceed, and where you resided at that time?

A. After my return in November, 1874, I did nothing until April, 1875; in the latter part of April, 1875, I read in one of the daily papers of Chicago, the "Chicago Tribune," of April 22d, 1875, a notice of an exhibition of a musical telephone; while walking home, on this day, with Mr. Frank L. Eastman, I referred to this article in the paper and asked him if he had read it; his answer was that he had not; I then explained to him as well as I could

2579

what the instrument was and what it had accomplished, and told him that I knew I could make an instrument that would carry speech from one place to another instead of musical sounds; he asked me why I did not go to work and do it, and I answered that I would; I spoke in regard to the commercial advantages of such an instrument, and told him that it would take the place of ordinary telegraph instruments; when we arrived at home, I showed him the drawings in the book marked "McDonough Drawing of August 26, 1871, F. A. Herring, Notary Public," referred to in my answer to the 15th question, and explained to him my ideas and method by which I intended to accomplish the result; we moved our business into the new store on Canal street, Chicago, about March 1st, 1875, and our residence from No. 584 West Washington street to No. 72 Warren avenue, Chicago, about May 1st, 1875; at that time the members of our household were Jeremiah E. Wilsey, Margaret V. Wilsey, his wife, who was my mother, John E. McDonough, Frank L. Eastman and Ada C. Eastman, his wife, who is my half sister, and myself; the house was painted and kalsomined after we moved in, occupying a week or ten days.

In the latter part of May I commenced work again on the speaking telephone; I had made for me two tin cases, and had the screw resoldered on the rod-iron magnet referred to in my answer to 21st question; one end of each of these cases I covered with a stretched parchment diaphragm; they were pasted to the tin and tied around with a string; one of these cases I used as a part of a receiver, and one as a part of a transmitter; the receiver was made by fastening the tin case by a screw which was soldered to it, to a wooden frame in such a position that the diaphragm was perpendicular to the frame.

Near the centre of the diaphragm was pasted a piece of tinned iron. In front of the tin case and diaphragm was placed the rod-iron magnet, fastened by the screw to a raised part of the frame.

The ends of the magnet were close to the tinned iron plate. The magnet was adjustable forward and backward. The part of the frame which supported the magnet could be moved on a pivot, formed by a screw passing through it.

A helix surrounded the magnet. It was formed by wrapping the magnet with insulated wire in the usual manner, and the ends of the wire connected with two screw-eyes screwed into the frame, and which served as binding screws.

The transmitter was formed by placing the other parchment-

covered tin case with the parchment diaphragm in a horizontal position upon a frame which had an arm of wood, which entended over the centre of the diaphragm.

Upon the centre of the parchment was fastened a small piece of thin German silver, which was connected by a wire to a screw-eye on top of the arm of the frame. Resting upon this piece of metal was a needle, which passed through a glass tube supported by the arm. The needle was free to move up and down in the glass tube; and was connected to another screw-eye by a thread of tin-foil.

This transmitter and receiver were first used in the latter part of May, 1875?

The receiver was placed upon a marble-top table in the second story front room of the house at 72 Warren avenue; the magnet of the receiver was placed in an electrical circuit, formed by carrying an insulated wire from one of the screw-eye binding posts to a galvanic battery; a wire was carried from the battery to a chandelier in the centre of the room, through a transom into a back room to the transmitter. A second wire was run from the other binding screw of the receiver to the chandelier, and through the transom to the transmitter, thus completing the circuit.

Recess taken until 2 o'clock P. M.

This set of instruments was operated by singing upon the diaphragm of the transmitter, the vibrations produced by the voice causing the diaphragm to vibrate, making and breaking the electric current at the point of contact between the needle and the piece of metal upon which it rested. This breaking of the current caused an alternate magnetization and demagnetization of the magnet of the receiver, attracting the piece of metal fastened to the membrane of the receiver and releasing it, causing it to vibrate together with the membrane, thereby producing sound which could be heard by the one at the receiver. This instrument was used and operated by myself and Mr. Eastman. We could recognize tunes, but no words.

Answer objected to by counsel for Gray, as inconsistent with and as a departure from witness' preliminary statement.

25th Q. Did any other person assist you, besides Mr. Eastman in making the experiment last referred to by you?

A. Mr. Wilsey and John E. McDonough listened at the receiver while myself or Mr. Eastman sang.

26th Q. Please state more particularly the location of the transmitter and of the receiver in your house at that time, how the one was closed as against the other, and their distance apart?

A. The receiver was placed in the front part of the front room, near a window and marble-top table, the battery along side of it on the table; the transmitter was placed in a back room of the same house on the same floor; the distance was about, in a straight line, forty feet. From the room in which the receiver was placed there was a door leading to a hall, with a transom over the door; the hall led past a wash room and a bedroom and to this back room, where there was a door that opened into the back room. When we operated the instruments the doors and transom were closed.

27th Q. Did you construct the whole or any of the parts of the instrument or device last described by you, and, if not the whole, what parts?

A. I constructed a part of it myself. I put the membranes on the tin cases of the receiver and transmitter. I made the frame on which the tin cases were placed. I wrapped the wire around the magnet, and put the receiver into its final shape. I put the piece of metal on the transmitter diaphragm and arranged it as I described it, with the needle resting upon the piece of metal and connected in circuit. I made the connections between the receiver and transmitter and with the battery.

28th Q. Which of the parts of such instrument as you have described were not constructed by you, and state by whom constructed, if you now recollect?

A. The tin cases were made by a tinsmith, on West Madison street, Chicago, by the name of Greenwalt; he also resoldered the screw on the rod-iron magnet. The battery and wires I bought some time prior to December 31, 1867. I bought the parchment pieces at some music store.

29th Q. State whether you now have in your possession the whole or any part of the instrumentalities which you have described in making the experiment, as last described by you, and if not, state what has become of the same, if you know?

A. I have a part of them, consisting of the tin cases, one of the stands, that for the transmitter, one of the screw eyes that was in the frame for the transmitter, and the needle that was used at that time. The frame for the receiver was used for the construction of

some other instrument; the wires and magnet of the receiver were used for the construction of another instrument. The parchments were destroyed in course of time or used for other purposes.

30th Q. Have you made, or caused to be made, a drawing of the instrumentalities or device used by you in making the experiments last described by you, and if so, will you produce such drawing?

A. I have caused a drawing to be made, and here produce it. It correctly represents the instruments as used at this time; the circuit connections are all so represented.

Counsel for McDonough offers said drawing in evidence, and the same is marked "McDonough Drawing No. 2." F. A. Herring, Notary Public.

31st Q. Did you subsequently make any change in the instrument or device as shown in "McDonough Drawing No. 2;" if so, when, and what change or changes did you so make?

A. I made an alteration in the transmitter, changing the posing of the screw eye and substituting for the thread of tin foil a thin strip of German silver, one end of which rested upon the needle, the other end was placed in connection with the circuit wire.

There was no change made in the receiver. This change was made about June 1, 1875.

32d Q. Have you made, or caused to be made, a drawing illustrating the change made in the transmitter which you have just described, and if so, will you produce such drawing?

A. I have had a drawing made, and I here produce it.

Counsel for McDonough offers said drawing in evidence, and the same is marked "McDonough Drawing, No. 3." F. A. Herrring, Notary public.

33d Q. State whether or not you made any tests of the instrument as last changed by you; and if so, when and where, and what were the results obtained?

A. I tested the instrument, together with Mr. Eastman, immediately after the alteration; the receiver was placed as before, the transmitter in the back room where it had been before, the circuit wires remaining the same and in the same place. We could hear with this instrument perfect tunes and could distinguish the

2553

McDONOUGH DRAWING No. 2.

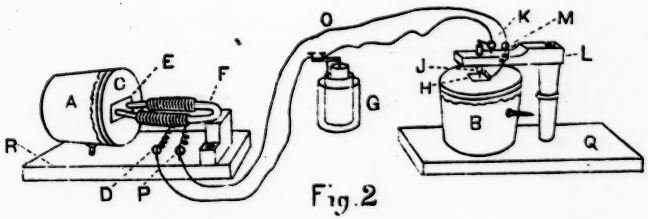


Fig. 2

A Tin Case of Receiver.
B Tin Case of Transmitter.
C Parchment Diaphragm.
D Screw Eye (binding screw).
E Iron Plate fastened to Diaphragm C.
F Magnet and Helix.
G Battery.
H Metal Plate on Transmitter Diaphragm.
J Glass Tube containing Needle.
K Screw Eye (binding screw).
L Frame of Wood holding Glass Tube and Screw Eyes.
M Screw Eye (binding screw).
O Direct Wire from Transmitter to Receiver,
P Screw Eye (binding screw).
Q Frame of Transmitter,
R Frame of Receiver.

F. A. HERRING,
Notary Public.

2524

Mc DONOUGH DRAWING No. 3.

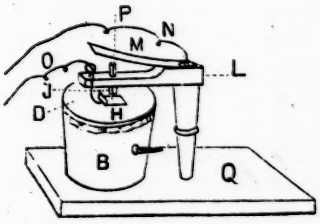


Fig. 3.

TRANSMITTER.

B Tin Case Transmitter covered with Parchment D.
D Parchment Diaphragm.
H Metal Plate upon which rests the Needle.
J Glass Tube containing Needle P.
L Wooden Frame supporting M, J, P.
N Wire to Receiver.
M Light Metal Strip resting on Needle.
O Wire to Battery.
P Steel Needle.
Q Frame of Transmitter.

F. A. HERRING,
Notary Public.

tone of the voice, but I do not remember of hearing any distinct words.

34th Q. Will you produce such parts of the instrumentalities which you used in the experiments last described by you, and which you now have in your possession; describing which of such parts are new or old?

I produce what parts I have left of the original instrument contained in the reconstructed instrument.

The same is offered in evidence by counsel for McDonough, which is marked respectively, "McDonough Receiver Exhibit, No. 1," and "McDonough Transmitter Exhibit, No. 2." F. A. Herring, Notary Public.

In the instrument marked McDonough Receiver Exhibit, No. 1, the original parts are the tin case with the screw soldered to it, and the movable L-shaped piece of wood which serves to support the magnet and adjust it to and from the diaphragm; all the other parts are duplications.

In the Transmitter marked McDonough Transmitter Exhibit, No. 2, the tin case, the entire wooden frame, the screw eye are original; the piece of glass tube, strip of metal and parchment and wires are duplications. The needle, now in the case of the Receiver, is one used during these experiments. The original magnet was used for another instrument, and the other parts reduplicated were lost or destroyed in time.

The dimensions of the instruments were as follows, namely, the diameter of the parchment diaphragms is five inches, the length of the cases is four and one-half inches, the small end of the transmitter case is entirely open, its diameter is four and one-quarter inches; it has a screw soldered to the outside of the case as shown in the two drawings.

The smaller end of the receiver tin case is four and one-quarter inches and is closed by a sheet of tin, with a hole three-fourths of an inch in diameter in the middle. The magnet of the receiver, which is a reduplication, as near as I can remember of the original, is horse-shoe magnet, each limb of which is six inches long, made of a quarter of an inch iron rod, a foot long, bent into horse-shoe shape, with a screw soldered at the base by which it is attached to the standard. The magnet is wound with a helix substantially as shown in drawing No. 2.

2526

35 Q. Please state what you next did toward perfecting your invention, when and where and with what instrumentalities?

A. At this time I had an iron hoop which I had used in 1867. I got a blacksmith to make a second iron hoop the same size of the first, with a screw attached on the outer flat-side of the hoop. I don't remember the man who made it. I think his shop was on Canal street, Chicago.

These two hoops I covered with parchment diaphragms, pasting the edges on the iron. When they dried they came off and I pasted a strip of cotton cloth on the hoops and pasted the parchment to this.

I made a receiver for telephonic transmission of articulate sounds by attaching the iron hoop to a frame by the screw. Near the center of the parchment diaphragm I fastened a piece of tinned iron with paste. Before this diaphragm was placed a magnet and helix taken from the receiver, described in my answer to the 24th question.

4.30 o'clock P. M., January 21, A. D. 1881, examination adjourned to same place at 9.30 o'clock A. M., January 22, A. D. 1881.

F. A. HERRING,
Notary Public.

January 22, 1881, 9.30 o'clock A. M.

Examination resumed at the same place, the same parties being present.

F. A. HERRING,
Notary Public.

Witness resumed his answer to the 35th question.

The ends of the wire forming the helix were attached to two screw eyes which served as binding posts. The magnet was supported by an arm moving upon a screw pivot somewhat smaller than that shown in the Receiver Exhibit No. 1, allowing the magnet to be adjusted forward and backward in front of the diaphragm. The ends of the magnet were directly in front of and close to the tinned iron piece pasted to the diaphragm.

The transmitter was formed by covering an iron hoop with a

parchment diaphragm. Near the center of the diaphragm two thin pieces of German silver were fastened with paste; they were separated by about a half inch. To each of these pieces of German silver was attached a light connecting wire. A thin piece of German silver was bent in an arch-shaped form and rested loosely upon the pieces of German silver fastened to the diaphragm.

While operating with the instruments described in my answers to the 24th question and the 31st question, we could distinguish some faint tones of the voice conveyed through the air from one room to another.

To obviate this we placed the transmitter just described in a back parlor down stairs, and connected it in electrical circuit with the receiver, which was placed upon the marble-top table near the window, in the second story front room of the same house.

One of the circuit wires passed from the screw-eye binding post to the receiver to the binding post of a galvanic battery, which was placed upon the marble top table at the side of the receiver.

Another wire passed from another binding screw of the battery to a chandelier in the center of the room, through a transom, across to a pair of stairs, and down the side of the stairs, across a hall, through a door, into a back parlor, where it was connected with one of the small wires attached to one of the pieces of German silver fastened to the diaphragm. Another wire was connected to the other small wire attached to the second piece of German silver pasted to the diaphragm.

This wire followed the course of the first wire to the chandelier, and from thence was carried to the other screw eye binding post of the receiver. The wires described above were all insulated.

The doors and transoms were closed while we operated these instruments, at this distance, and no trace of any sound could be distinguished as passing through the air when we tested this instrument by singing in front of the transmitting diaphragm. I found that the piece of arch-shaped metal resting upon the two flat pieces of German silver pasted to the diaphragm was shaken off by the vibrations, and I proceeded to attach it to prevent it from doing so. I passed a piece of thread through a hole in the center of the arch-shaped piece of metal, which I punched for that purpose, down through a hole in the diaphragm between the two pieces of metal pasted thereon, tying a knot in the thread under the diaphragm and another on top of the arched piece of metal. This held the piece of metal in place and we twisted the thread to tighten it.

2528

The ends of the arched piece of metal rested upon the two pieces of metal pasted to the diaphragm, completing the electrical circuit. The current coming from one pole of the battery passed to one of the pieces of German silver, thence through the arched piece of metal to the other piece of German silver, from thence, by the conducting wire, through the helix through the magnet of the receiver to the other pole of the battery. We operated this instrument as now arranged by singing in front of the transmitter and listening at the receiver up-stairs. This instrument was operated by Mr. Eastman and myself. We could distinguish tunes and some words distinctly. I then had made a screw pin of brass. This screw pin was formed of a small piece of brass wire about an inch long; a screw thread was turned on each end; at about one-third of the distance from one end a small lead nut was fastened. Another small movable lead nut was screwed on at the same end, and another of the same size was screwed on the other end of the brass wire.

I put this screw pin in the place of the piece of thread with the knots.

The pin was attached to the diaphragm by passing one end through the diaphragm and screwing a nut against the other side of the diaphragm, opposite the stationary nut.

This pin stood at right angles with the diaphragm projecting above it about two-thirds of its length. The arch-shaped piece of metal was placed as before, the pin passing through the hole in the center, and a nut was screwed on the top of the pin.

The position of the transmitter and receiver was not altered; the circuit wires and battery remained the same and in the same positions; the course of the current was the same.

I was assisted in operating this instrument by Frank L. Eastman, Jeremiah E. Wilsey and John E. McDonough.

We obtained results as follows, viz.: clearly recognizable tunes, and entire sentences of clearly understood words were transmitted through the instruments and heard at the receiver.

This iron-hoop receiver and transmitter, with a thread attachment, were completed about the middle of June, 1875.

The substitution of the screw pin for the thread in the transmitter followed shortly after, and the operation of the last described instrument took place in the last week in June, 1875; the precise day I cannot tell. These results were obtained at the house known as No. 72 Warren avenue, Chicago.

I was not able to state the exact day, and in my preliminary statement fixed on the last day of June, 1875, as the latest day upon which we obtained the described results.

36th Q. State any circumstance that enables you to fix the dates last mentioned by you.

A. We moved into the house on Warren avenue the first week in May, 1875, and were about a week or ten days unsettled. Toward the latter end of May, 1875, I commenced working on this, and continued to the latter end of June, 1875.

Mr. and Mrs. Eastman and myself were at Highland Park on the 4th of July, 1875. Mr. Eastman and myself had some conversation regarding this subject of the telephone. After returning, I started on a vacation about the second week in July, and was gone possibly six weeks.

37th Q. Are you positive from the circumstances which you have stated, that the devices or instrumentalities which you last described were operated and the results produced, as stated by you, prior to the 4th day of July, and as early as the thirtieth day of June, A. D. 1875?

Objected to as leading and incompetent.

A. I am positive that the instruments were used at that time, and the results described obtained.

38th Q. Can you state what tunes or spoken words were transmitted and heard through the instruments that you have last described at the date mentioned by you?

A. To my own knowledge the tunes were, "Swanee River," "Muffin's Man," "Shoe Fly" and some others. The words which impressed themselves upon me more particularly were "Way down upon the Swanee Ribber, far, far away," which I heard consecutively and clearly, noticing the elison at the beginning of the word "way," and the change of "v" to "b" in the word "river." The words of other tunes were distinct when the instruments were properly regulated.

I, myself, could distinguish peculiarities of voice in those speaking or singing.

I don't remember what spoken words, if any, were used at this time.

39th Q. You state that you could distinguish peculiarities of

2530

voice. Am I to understand that you could recognize the voice of the person singing or speaking through the instruments?

Objected to as leading and incompetent.

A. When I could distinctly understand the words I could.

40th Q. You have stated the names of some persons who assisted you in operating the instrument and in producing the results you have described. Will you now state the names of persons, if any, who had knowledge of the result produced by such instruments, at or about the time named by you?

A. My mother and sister knew of the results, probably, by hearsay, during the fall of the year 1875. I told several persons that I had made and successfully operated an instrument for the transmission of vocal sounds telegraphically.

Among these last were T. B. Jeffery, who made the screw pin for me described in the instrument, S. G. Wilkins, Calvin Cobb, and L. M. Cobb and some others.

41st Q. Have you made, or caused to be made, a drawing illustrating the instruments last described by you, and if so, will you produce such drawing?

A. I have caused a drawing thereof to be made, and I hereby produce the same.

Counsel for McDonough offers the drawing in evidence, and the same is marked "McDonough Drawing No. 4."

F. A. HERRING,
Notary Public.

42d Q. Did you construct in whole or in part, the instruments last described by you, and as shown in drawing No. 4; and if not, who assisted you in constructing such instruments?

A. I constructed them in part, the iron hoops were made by blacksmiths, the magnet of the receiver was one taken from the instrument described in my answer to 24th question; the screw pin in the transmitter with the nuts attached was made by T. B. Jeffery, a model maker on Canal street, Chicago; I made the frame or base of the receiver myself; I put the diaphragms on the hoops, constructed and attached the pieces of metal to the transmitter, and arranged and put the entire instrument in the shape as described.

43d Q. Have you the instrument referred to, or any of the parts

2531

McDONOUGH DRAWING No. 4.

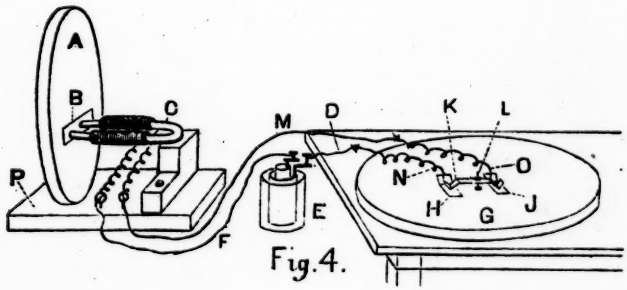


Fig. 4.

RECEIVER. TRANSMITTER.

A Parchment Diaphragm stretched on Iron Hoop.
B Iron Plate fastened to Diaphragm.
C Magnet and Helix.
D Wires from Battery to Wire N.
E Battery.
F Wire from Battery to Receiver.
G Parchment Diaphragm of Transmitter.
H Metal Plate fastened to Diaphragm.
J Metal Plate fastened to Diaphragm.
K Circuit Breaker formed of light strip of metal.
L Bolt with Nut for confining and Regulating K.
M Direct Wire from Transmitter to Receiver.
N Wire from H to Battery.
O Wire from J to M.
P Frame of Receiver.

F. A. HERRING,
Notary Public.

thereof, now in your possession, or under your control; and if not, what has become of such instrument or parts thereof?

12.30 o'clock P. M. Recess taken until 2 o'clock this P. M.

F. A. HERRING,
Notary Public.

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2 o'CLOCK P. M., Jan. 22, 1881.

Examination resumed, at same place; same parties being present.

F. A. HERRING,
Notary Public.

Witness in answer to 43d question says as follows, viz.:

A. I have a part of the instruments, one of the iron rings, the magnet, part of the helix, the brass screw-pin and small wires of the transmitter were put into a model which was sent with my application to the Patent Office.

The ends of the magnet were cut off to reduce the size to that required by the Patent Office.

The parchments were cut up to furnish diaphragms for the same model. The second iron ring has been lost; the frame of the receiver was used for other instruments, and I do not know what finally became of it.

The battery I have yet in a ruined condition, worn out; the circuit wires were used up in other experiments.

44th Q. Have you made or reproduced the instruments last referred to, and as shown in McDonough's Drawing No. 4, in whole or in part, and if so, will you now produce the same?

A. I have made a duplication of these instruments, using the iron ring as a part. The other parts are all duplications. I here produce the duplicate of the receiver and transmitter. In my description of this transmitter I said that the two pieces of metal pasted to the diaphragm were a half inch apart; I should have said an inch and a half.

The parchment pieces on the receiver were not in the original, but are placed to fasten the German silver pieces more securely than they were originally.

The piece of parchment, covering and holding in place the piece

of tinned iron of the receiver diaphragm, is also placed there for the purpose of preventing the piece from being lost.

45th Q. Do the duplicates that you now produce correctly represent respectively the construction, form and dimensions of the receiver and transmitter, with the exceptions you have stated, and what are the dimensions of such duplicate instruments?

A. They do. The dimensions are as follows, viz: The internal diameter of the hoop is 12 inches; the hoops are about an inch wide, and of about one-eighth ($\frac{1}{8}$) inch iron. The pieces of German silver fastened to the diaphragm are about one inch and a half ($1\frac{1}{2}$) long and a half ($\frac{1}{2}$) inch wide, turned up at the end a quarter of an inch to three-eighths ($\frac{3}{8}$) inch. The bridge piece is three-eighths ($\frac{3}{8}$) of an inch high, and the distance between the points that rest on the German silver pieces is one and thirteen-sixteenth inches; the width is five-sixteenths of an inch. I can't tell the thickness of the German silver. It is pretty thin—such as ordinarily used for making small stencil plates.

Counsel for McDonough offers the said instruments in evidence, and they are marked respectively "McDonough Transmitter, Exhibit No. 3," and "McDonough Receiver, Exhibit No. 4." F. A. Herring, Notary Public.

46th Q. State, if you recollect, the date of the filing of your application for letters patent involved in this interference?

A. April 10, 1876.

47th Q. Why did you delay filing your application for letters patent to that time?

A. The sounds which we received from this instrument were not very loud. It was necessary to hold the ear within four or five inches of the receiving diaphragm to understand words.

I thought I could make an instrument which we could hear in any part of the room. After accomplishing the results heretofore described, it was absolutely necessary that I should quit work and take a vacation. When I arrived at home I commenced work about the first of September, 1875, on new instruments for the purpose of increasing the volume of sound. I made probably fifteen different instruments, not differing in principle from that of the last of June, 1875.

I had diaphragms, varying from one and one-half inches to fifteen inches in diameter. I used larger and smaller size mag-

2534

nets, and from one to eight cells of battery. I substituted other kinds of metal for the German silver in the transmitter; for the receiver diaphragm was substituted a wooden box of light wood, to which the tinned iron was pasted. I had a receiver in which the diaphragm was the end of a tin case which I had made. Not having obtained anything which gave it a louder articulation, and being urged by those around me, I made my application at the time stated.

48th Q. Was your time wholly occupied between the 30th day of June, 1875, and the 10th day of April, 1876, in your attempts to increase the volume of sound in the instruments which you have described?

Objected to as leading and incompetent.

A. No; I was in Highland Park the day of the 4th of July; I was on a vacation for six weeks. Most of my time in the day was occupied in business. I worked for this object nights and mornings at every opportunity.

49th Q. Between the dates mentioned, what was your regular business, and the name of the firm with which you were connected?

A. My regular business was that of a furniture manufacturer. I had the general supervision of the business and special supervision of manufactures. The name of the firm was McDonough, Price & Co.

The foregoing deposition, and particularly the 31st to 35th answers, inclusive, objected to as not warranted by the preliminary statement, application and issue.

CROSS-EXAMINATION BY MR. STORROW:

50th Cross-Q. Have you stated all that you did or accomplished relative to the electrical transmission of sound prior to April 10, 1876?

A. I have not described with full details all of the instruments made between June 30th, 1875, and April 10th, 1876.

51st Cross-Q. I understand from your 47th answer that during that time you made probably fifteen instruments, and that none of them differed in principle from that of the last of June, 1875; is that the fact?

A. In the general principle they did not differ.

2535

52d Cross-Q. I understand that your instruments of the last of June, 1876, are, as near as you can recollect, correctly represented by McDonough Drawing No. 4; is that so?

A. I believe them to be so, with the exception that the diaphragm of the transmitter in the drawing should be the same size as that of the receiver in the same drawing.

53d Cross-Q. Was the instrument and apparatus of the last of June, 1875, the same in its principle and mode of operation as the instruments desribed in your application of April 10, 1876?

A. Yes, it was substantially the same.

54th Cross-Q. If there was any difference between them, please point it out?

A. In the instrument applied for in the application there was a wooden frame attached as a baseboard to the transmitter hoop; and the hoop of the receiver was also attached to a wooden frame, in an upright position; the operation of the instruments was not different.

54½th Cross-Q. The original drawing, of which you have put in a *fac simile*, marked McDonough Drawing of August 26, 1871, was in pencil, was it not?

A. Yes.

55th Cross-Q. The drawings marked McDonough Drawings Nos. 1, 2 and 3 respectively, have been made by you, or under your direction, within a few weeks, as part of the preparation for taking your deposition, have they not?

A. No, they were not made within a few weeks; they were made about two months ago.

56th Cross-Q. I understand that they are prepared from your recollection and from such parts of the original instruments as you have produced and identified; is that the fact?

A. Yes.

5 o'clock P. M., }
January 22, 1881. }

Examination adjourned to Monday, January 24, 1881, 9.30 o'clock A. M., at same place.

F. A. HERRING,
Notary Public.

MONDAY, January 24, 1881,
9.30 A. M.

Cross-examination resumed, the same parties being present.

F. A. HERRING,
Notary Public.

57th Cross-Q. Please look at your 40th answer, and tell me what business or other connection you had or have with the last three persons mentioned?

A. S. G. Wilkins was bookkeeper for McDonough, Wilsey & Co. He is now a member of the firm of Eastman & Wilkens, our successors. Calvin and L. M. Cobb have been friends of mine for a number of years.

58th Cross-Q. Have you had knowledge from time to time of the official correspondence between the Patent Office and your solicitor with reference to your interfering application?

A. Yes.

59th Cross-Q. You were personally present when depositions on the part of Mr. Gray were taken in the telephone interferences in May, 1880, in Chicago, were you not?

A. I was present part of the time.

60th Cross-Q. At that time, or shortly after, you were furnished with the printed volumes of the testimony in the "Telephone Suites" Bell Co. vs. Dowd, were you not?

A. Yes; it was shortly after that.

CROSS-EXAMINATION BY WILLIAM D. BALDWIN, ESQ., COUNSEL FOR GRAY:

61st Cross-Q. Please state what works on physics, including electricity, you had read prior to 1866?

A. Our text-book in school. I think it was "Parker's Philosophy." I had another text-book beside that, of which I do not remember the name, on the same subject; Tyndall's works on heat, light and sound; the "American Annual of Scientific Discovery," "The Scientific American," and encyclopedias and general works on the subject of physics, in libraries and book stores.

62d Cross-Q. Did you ever read Davis' "Manuel of Magnetism?"

A. I don't remember the book. I never heard of it, to my present knowledge.

63d Cross-Q. What led you to use a parchment diaphragm?

A. I suppose I used parchment because I had seen it on banjo heads, and knew it to be good material for diaphragm.

64th Cross-Q. Had you any particular object in using an iron hoop as a support for your diaphragms, instead of any other material?

A. No; I merely made it strong enough to hold the diaphragm securely.

65th Cross-Q. What called your attention to the subject of electrical transmission of sounds April, 1874, as stated in your 21st answer?

A. It was called to the subject again through general study of electricity and by looking over my drawings.

66th Cross-Q. When did you first hear of Elisha Gray's invention of the harmonic telegraph or telephone?

A. I think the first I ever heard of Mr. Gray's inventions was in April, 1875.

67th Cross-Q. Had you, prior to April, 1874, any acquaintance among the telegraphic fraternity of Chicago?

A. No general acquaintance.

68th Cross-Q. How much of your time did you spend in England between May and November, 1874?

A. At different times; three or four weeks.

69th Cross-Q. Did you meet Gray while abroad or hear of his telephonic inventions?

A. I did not meet him. I have no remembrance of his inventions prior to the spring of 1875.

70th Cross-Q. Was it Gray's exhibition of a musical telephone that you read of in the "Chicago Tribune" of April 22, 1875?

A. Yes, it was.

71st Cross-Q. What led you to select tin or tinned iron for the cases of your instrument of May, 1875?

A. It was because it was easy to make them of that and it was cheap.

72d Cross-Q. Why did you make them in the shape of the frustrum of a cone instead of cylindrical?

A. I don't believe I had any particular object in having them constructed in that way.

73d Cross-Q. Had you any particular object in making them of the diameter you did?

A. No; only to keep them from costing too much.

2558

74th Cross-Q. What particular object had you in using a German silver patch on the transmitting diaphragm?

A. No particular object as to the metal. I could get a light, hard piece of metal that way, which was a conductor of electricity.

75th Cross-Q. Did you meet Elisha Gray during your visit to Highland Park, July 4, 1875, referred to in your 36th answer?

A. No; the first time I ever met Mr. Gray was at a lecture in McCormick Hall in this city in 1878, I think.

76th Cross-Q. On what ground were you urged by those around you to file your interfering application, as stated in your 47th answer?

A. I told them that it would be my luck to have somebody else get ahead of me, and I worried over it somewhat, and they urged me to make my application because I had got good results and ought not to wait.

77th Cross-Q. Have you assigned or agreed to assign this invention or any interest therein to any one, or do you still own the entire interest?

A. I have made a provisional contract to assign my patents in regard to this invention, which I may hereafter obtain, to the American Bell Telephone Company.

78th Cross-Q. When was this contract made?

A. It was about the first day of November, 1880.

79th Cross-Q. Is that contract verbal or in writing?

A. In writing.

Counsel for Gray calls for the production of the contract, that it or such portions of it as may be deemed material may be used as evidence in the case.

Witness states that the contract with the American Bell Telephone Company is a private contract, his compensation depending upon his obtaining a patent for his invention, and that under instructions from his counsel he declines to produce said contract.

Further cross-examination declined by counsel for Gray.

JAMES W. MCDONOUGH.

Subscribed and sworn to before me this 24th day of January, A. D. 1881.

[L. S.] FREDERICK A. HERRING,
Notary Public.

2539

January 24, 1881, 12 o'clock, M.

Examination adjourned to 2 o'clock, P. M., to-day, at same place.

F. A. HERRING,
Notary Public.

January 24, A. D. 1881, 2 o'clock P. M.

Examination resumed at same place.

F. A. HERRING,
Notary Public.

FRANK L. EASTMAN, being first duly sworn, does depose and say, in answer to interrogatories proposed to him by N. C. Gridley, Esq., counsel for James W. McDonough, as follows, viz:

1st Q. What is your name, age, residence and occupation?

A. Frank L. Eastman; thirty years of age; residence, 385 West Randolph street, Chicago, Illinois, and my occupation is that of a furniture manufacturer. Am of the firm of Eastman & Wilkins, and am a brother-in-law of James W. McDonough.

2d. Are you acquainted with the subject matter involved in this interference?

A. Yes, sir; I believe I am.

3d Q. When, for the first time, was your attention called to the idea of transmitting sound or articulate speech, telegraphically or by means of what is now known as a telephone, and by whom and under what circumstances?

A. It was some time in the spring of 1874, by Mr. J. W. McDonough. We were looking through a book in which he had some drawings of different instruments. He said he thought it was possible to send speech over a wire. There was other talk about it, but that is about all that was said about it at that time. He showed me a drawing of a machine that he had made previously for that purpose.

4th Q. Where did this conversation take place?

A. At our house, No. 584 West Washington street, Chicago.

5th Q. Can you name more particularly the month and day of the month?

A It was before the first of May; I can't give it any closer than that.

6th Q. Were you a member of the same family with Mr. McDonough at that time?

A. I was boarding with his family.

7th Q. Please look at the book now handed you and state whether or not that is the book to which Mr. McDonough called your attention?

A. Yes, sir; it is.

8th Q. Please identify and point out, if you can, the drawing in that book to which he directed your attention?

A. I can't positively identify it, but I think that this drawing is the one.

Referring to the drawing marked "McDonough Drawing, August 26, 1871." F. A. Herring, Notary Public.

9th Q. What further was said, if anything, by Mr. McDonough to you at that time, in reference to his idea of telegraphic transmission of sound and speech?

A. Nothing that I can remember.

10th Q. State when your attention was next called to this subject—where, by whom, and under what circumstances?

A. It was in April, I think, 1875, by Mr. McDonough, as we were coming home together. He asked me if I had read a notice in a paper in regard to sending musical tone sounds through wire. I told him that I had not, and he gave me a description of the notice, and he said, "Frank, I know that I can make a machine that will send speech over a wire;" and I said, "If you know you can do it, why don't you?" He then asked me if I remembered his speaking about it the year before. As soon as we reached the house, he got this book with his drawings and showed me this sketch of this instrument, which he had shown me the year before; he then went into the garret and picked out from an old box several pieces of a telegraphic machine, an old magnet, and a lot of wire, which he said he had used previously in some experiments, and he said he would fix them up and try and make a machine, or what is now called a telephone.

11th Q. Did he state at that time what he expected to accomplish by the machine that he proposed to make?

A. Yes; he said with such a machine it would be possible for one person to talk with another through a wire from Chicago to New York; and he gave several other illustrations of its use.

2541

12th Q. What circumstances, if any, enable you to fix the date of this conversation as taking place in April, 1875?

A. I know it was a short time before we removed to number 72 Warren avenue; we moved to 72 Warren avenue about the first of May, 1875.

13th Q. Please state, if you know, what Mr. McDonough next did toward the development of his idea for the transmission of articulate speech telegraphically, and how soon after moving into the Warren avenue house?

A. I do not remember anything that was done by Mr. McDonough until after we removed to Warren avenue; but within a few days after removal he commenced his experiments on this machine.

The first instrument that I remember I will describe as near as I can:

He had a tin cylinder made, I should say it was five or six inches in diameter. Over one end of this he pasted a piece of parchment. On to the outside of the parchment he pasted a piece of metal. There were two of these tin cylinders, both about the same thing. Then he made a wooden arm or bracket, which overhung the cylinder. He made a hole in one end of the bracket and placed a common needle through the hole, which reached down and rested on the piece of metal, the top of the needle projecting through the hole in the bracket.

He attached a wire to the piece of metal which was pasted on to the parchment, and to the top of the needle he attached a piece of tin foil; to this tin foil he attached another wire. Both of these wires ran from this tin cylinder which was located in a rear room of our house into a front room where these wires were connected with a magnet and a battery in some way. In this front room he placed the other cylinder before the magnet.

That is as close a description as I can give of the instrument which he first made.

14th Q. State, if you can, how the magnet was constructed and how arranged in front of the cylinder provided with parchment in the front room?

A. As I remember it, the magnet was made from a piece of bent iron in the shape of something like a horse-shoe. This iron was wound round with a wire, and was raised up in some way so that he two ends of the magnet were opposite the middle of the cylinder

and opposite the piece of metal which was pasted on the parchment.

15th Q. Please look at the instruments now shown you and marked respectively "McDonough Receiver Exhibit No. 1," and "McDonough Transmitter Exhibit No. 2," and state how they compare with the instruments you have described, and if different in any particulars, state wherein?

A. They are almost exactly the same thing; I think that this magnet and the wire which is wound around it are not exactly the same as the instrument I described.

I think that the piece of iron forming the magnet was longer, but I can't see any other difference; yes, there was more wire surrounding the piece of iron, as I remember it; there may be some other difference, but these are about the same instruments.

After some experiments with the needle of the transmitter running through the hole in the wood, Mr. McDonough inserted a piece of glass tube through the hole in the bracket and ran the needle through the glass tube, as he said there was too much friction with the needle running against the wood; he also took off the piece of tin foil and replaced it with a piece of spring steel, I believe it was, and afterwards with a piece of German silver.

16th Q. State what experiments, if any, were made by Mr. McDonough with the instrumentalities you have described, who assisted him in making such experiments, and state particularly the results produced?

A. The experiment was made of talking and singing into the transmitter; I assisted him at different times when we were home together; at other times he was assisted by his sister and his brother and Mr. Wilsey.

The results from these experiments as heard at the other end or in the receiver was a variation of rattling sound and musical tones.

17th Q. What change, if any, was made at this time in the position of the transmitter and receiver relatively to each other, and if any made, why so made?

A. We found that the talking and singing could be heard through the walls of the rooms, and so the transmitter was carried down on the first floor into the rear room of the house, where there was no interference from the sound of the voices coming through the doors or wall.

25473

We made many experiments with this machine, and at times we could distinguish the tune that was sung.

18th Q. State whether or not there were any changes made in the instrumentalities or devices you have described, and if so what changes, by whom, and what were the results produced consequent upon such changes?

A. The tin cylinders were changed for large iron rings fitted up with parchment in about the same manner as Mr. McDonough thought the diaphragm or parchment was too small in the tin cylinders.

Instead of one piece of metal being pasted on to the parchment of the transmitter there were two and Mr. McDonough gave up the needle, as he could find no way to keep it from jumping, and the needle was replaced by a piece of thin metal in shape like an inverted V with a square top to it. The feet of this piece of metal were placed, one on each of the strips of metal which were pasted on to the parchment, and through the top of this V-shaped piece of metal was run a wire through the parchment and fastened on the under side of the parchment I believe. The top of this wire was supplied with a nut by means of which this metal arch could be held firmly down on to the diaphragm or loosened as desired. The tin cylinder at the receiving end was also changed for a large iron ring covered with parchment and with a metal strip pasted to it.

By experiments with this new machine we were able to recognize the voice of the person singing, the tune that was sung and many of the words of the tune, also, we could understand words that were spoken, and could recognize the voice of the person speaking.

19th Q. Please look at the instruments now shown you and marked respectively, "McDonough Transmitter Exhibit No. 3," and "McDonough Receiver Exhibit No. 4," and state how they compare with the instruments constructed by Mr. McDonough as last described by you?

A. They are substantially the same instruments in the construction.

I should have said in my description of the transmitter that one wire was attached to each of the two strips of metal that were pasted on to the parchment.

20th Q. If you recollect, state what experiment was made, if any, by Mr. McDonough, for holding the arch-shaped piece of metal or circuit-breaker in position, prior to his making use of the screw pin and nut, as shown in this instrument?

A. He first tied the metal arch down with a piece of string run-

25244

ning through the top of the arch, and, I believe, through the parchment, and tightening the string by twisting it, but he found he could not regulate the instrument fine enough with the string, and so he replaced it with the nut and bolt.

21st Q. How often did you operate the instruments as last constructed by Mr. McDonough and as shown in these exhibits, in connection with Mr. McDonough; and state, if you now recollect, what tunes or songs and what spoken words you heard at the receiver?

A. I assisted Mr. McDonough in operating the machine whenever I had time, and we were home together generally every evening, and I guess we exhausted all the songs we ever heard.

I can give you the names of a few of them, others I don't remember. They were "Swanee River," "Down in the Coal Mine," "Old Zip Coon" and others that I have forgotten. I heard many of the words of these songs, exactly which words I can't remember.

I also heard Mr. McDonough say: "Halloo, Frank!" and other words that I can't remember now.

22d Q. At the time of operating the instruments, as last spoken of by you, what was the distance between the receiver and the transmitter, and state whether or not the doors and transoms of the rooms in which the instruments were placed respectively were open or closed?

A. The distance between the receiver and transmitter I should say was between seventy and a hundred feet, one being in the front room of the second floor, and the other in the rear room of the first floor.

The doors and transoms were shut as tight as we could make them.

23d Q. Please describe the course of the circuit wires from the transmitter to the receiver and how they were held in position?

A. I don't know as I can describe it exactly, but as near as I can remember it was as follows, viz.: The transmitter stood on a table in the rear room of the first floor. The wires ran first to the chandelier, through the transom, across the parlor, and through that to a room upstairs, through a long hall, over a transom, and were fastened to a chandelier, and from that down to the battery and magnet. They were held in position by shutting the transoms on to the wires and by winding the wires around the gas fixtures.

4.30 o'clock P. M., January 24, 1881.

Examination adjourned to to-morrow at 9.30 A. M., at same place.

F. A. HERRING,
Notary Public.

January 25, A. D. 1881,
9.30 o'clock A. M.

Examination resumed, all the parties being present.

F. A. HERRING,
Notary Public.

24th Q. When were the devices or instrumentalities completed and operated, and the results produced by Mr. McDonough with your assistance as last described by you?

A. I remember that it was before the 4th of July, 1875, and after we moved into the Warren avenue house. I remember this from the fact that on the 4th of July, 1875, I, with Mr. McDonough's family, went to Highland Park, on a picnic, and while at Highland Park the subject of this telephone was discussed. I also remember that it was previous to the 26th day of June, 1875. On the 26th day of June, 1875, I left Chicago to visit my father and mother in Michigan, and told them of Mr. McDonough's experiment with this machine, and the results obtained. While at the breakfast table I said, "Now, if we only had Mac's machine rigged up we could ask them what they were having for breakfast in Chicago."

25th Q. After the results produced by Mr. McDonough with the instrumentalities described by you, what further, if anything, was done by Mr. McDonough with such devices or instrumentalities, or others, and when?

A. Mr. McDonough made a number of other machines and changes in this machine, hoping to increase the volume of sound and the distinctness. This was during the fall of 1875.

26th Q. Do you know of Mr. McDonough's making a visit to Europe at any time, and if so, when and for what purpose?

A. Yes, sir; Mr. McDonough went to Europe some time in the spring of 1874. I think he left Chicago in May. He went for the benefit of his health, he having been in very poor health from the time that I first became acquainted with him, which was in 1872, I believe.

2546

CROSS-EXAMINATION BY J. J. STORROW, ESQ., COUNSEL FOR BELL:

27th Cross-Q. When did you first become an inmate of Mr. McDonough's household?

A. In 1873, May or June.

28th Cross-Q. Have you lived together ever since?

A. Yes, sir.

29th Cross-Q. In "McDonough's transmitter, Exhibit No. 3," the ends of the bridge-piece are turned up like Vs, so that only the folded edges rest on the German silver contact pieces. Were they turned up in that manner the first time you saw the original, of which this Exhibit purports to be a reproduction?

A. I believe they were.

30th Cross-Q. Why were they turned up so, instead of being allowed to rest flat on the contact pieces?

A. That I do not know.

31st Cross-Q. When did you last see the original of which you say said Exhibit No. 3 is a reproduction?

A. I have seen it a number of times since the first experiments with it, but don't remember when I last saw it.

32d Cross-Q. Where did you last see it?

A. I think it was at No. 72 Warren avenue.

33d Cross-Q. What part of the house?

A. I don't remember that.

34th Cross-Q. What became of it afterwards?

A. I do not know.

35th Cross-Q. Then you don't remember when you saw it last, or where you saw it last, nor what came of it afterwards, do you?

A. I said before that I thought I saw it at No. 72 Warren avenue after the time we made our first experiments with it; what became of it afterwards I do not know.

36th Cross-Q. But you don't remember what part of the house you saw it in, do you, on the last occasion?

A. No, sir.

37th Cross-Q. When and where did you last see the original of which you say McDonough's Receiver No. 4 is a reproduction?

A. At No. 72 Warren avenue, at the same time that I saw the transmitter.

38th Cross-Q. Can't you fix the time and place any more definite, yet, than that?

A. No, sir.

254

39th Cross-Q. When and where did you last see the original of which you say "McDonough's Transmitter No. 2" is a reproduction?

A. I remember having seen it at No. 72 Warren avenue, in 1875, after July 1st; I can't fix any particular date—probably saw it many times.

40th Cross-Q. When did you first see these reproductions Transmitter Exhibit No. 3, and Receiver Exhibit No. 4?

A. I first saw them, as they are now, within the last ten days.

41st Cross-Q. What condition were they in when you saw them before that?

A. I can't say that I ever saw them before that.

42d Cross-Q. When did Mr. McDonough make these particular Exhibits?

A. I do not know.

43d Cross-Q. When did you first know that they were made, or that he was making them?

A. I first knew that they were made at the time I first saw them within the last ten days.

44th Cross-Q. Before that time you had heard that they were being made or were to be made, had you not?

A. I believe Mr. McDonough said that he was making or fixing something of the kind in his work room, but I had not seen them.

45th Cross-Q. When did you first see the instruments now on the table before you, Receiver Exhibit No. 1 and "Transmitter Exhibit No. 2?"

A. I first saw them here in this office yesterday, as they are now.

46th Cross-Q. What condition were they in when you saw them the last time before yesterday?

A. I believe they were in about the same condition, with the exception of the magnet and wire.

47th Cross-Q. What difference was there in the magnet and wire at that time?

A. I can't tell the exact difference except that this, I believe; not the same piece of iron in the magnet nor the same wire.

48th Cross-Q. What was that occasion which you refer to when you saw them with a different magnet and a different wire?

A. That was in June, 1875.

49th Cross-Q. Do you mean that you didn't see them between June, 1875, and yesterday?

2548

A. Well, I never saw them as they are now till yesterday. I have seen the tin cylinders since June, 1875.

50th Cross-Q. What is the difference between the condition they are now in and the condition they were in on the occasion when you last saw them before yesterday; I refer to the two instruments No. 1 and No. 2?

A. At the time I last saw this transmitter, No. 2, I should say it was in the same shape that it is now, but the Receiver No. 1 either had no magnet at all before it or else it was a different magnet from this one.

51st Cross-Q. Now, please give the date of the occasion referred to in your last answer?

A. That was some time in 1875 after Mr. McDonough had stopped using them.

52d Cross-Q. When you first saw the Exhibits No. 3 and No. 4, were they exactly in the same condition that they are now in?

A. No, sir; they were connected with wires and with a battery, I believe.

53d Cross-Q. When was that?

A. That was within the last ten days.

54th Cross-Q. Were the instruments themselves, apart from the connecting wire and battery, on that occasion in the same condition they are now in, in all their parts, or have any parts in them been changed or replaced since?

A. I think they were in the same condition that they are now in; I can see no difference.

55th Cross-Q. Where were they on that occasion?

A. They were at No. 385 West Randolph street, where Mr. McDonough and I reside.

56th Cross-Q. Was that the first time when you saw a couple of instruments made and intended to be reproductions of the originals, which you say No. 3 and No. 4 are reproductions of?

A. I am not certain about that. Mr. McDonough made a number of machines since the original, and I may have seen them; I don't remember positively.

57th Cross-Q. Have you, at any time within the last year, seen any instruments which purported to be, or were supposed to be, reproductions of the originals of which you say Nos. 3 and 4 are reproductions?

A. I do not remember to have seen any.

2549

Further cross-examination waived by counsel for Gray.

FRANK L. EASTMAN.

Subscribed and sworn to before me, this 25th day of January, A. D. 1881.

[SEAL] FREDERICK A. HERRING,
Notary Public.

JEREMIAH E. WILSEY, being first duly sworn, does depose and say in answer to interrogatories proposed to him by N. C. Gridley, Esq., counsel for James W. McDonough, as follows, viz:

First Question. What is your name, age, residence and occupation?

A. Jeremiah E. Wilsey; fifty-five years of age; No. 385 Randolph street, Chicago, and I have not been doing anything for the last two years. I am out of business.

2d Q. Prior to the last two years, in what business were you engaged, and of what firm or firms were you a member?

A. I was engaged in the furniture, general upholstering business, and was a member of the firm of McDonough, Wilsey & Co., last.

3d Q. Are you acquainted with James W. McDonough one of the parties to this interference, and how long have you known him?

A. Yes, sir; I am acquainted with him. I have known him since he was about five or six years old.

4th Q. Are you related to him by blood or marriage, and how long has he been a member of your family?

A. I am related to him by marriage; I am his step-father. He has been a member of my family ever since 1852.

5th Q. Have you been informed as to the subject matter involved in this interference?

A. Yes, sir.

6th Q. Please state when, for the first time, the idea of transmitting sounds telegraphically was made known to you, where, by whom, and under what circumstances?

A. I think it was in 1867. Mr. McDonough told me he thought he could send sound over telegraph wire. It was at No. 114 South Jefferson street, Chicago, where we lived at that time.

I think he was sick at the time. I have an impression it was from a fractured leg. He had a book with him and some drawings and pencils. He had some papers in the book with the drawings;

2550

he was drawing in the book. I don't recollect any of the drawings now in the book, with the exception of one, and that was a machine for counting envelopes or something of that description. And I was asking him what they were, and he told me what they were; and among other things he told what he thought he could do with the telegraph.

7th Q. What time in the year 1867 was it that you had this conversation with Mr. McDonough?

A. I couldn't tell. I couldn't recollect.

8th Q. State whether or not Mr. McDonough, at or about the time referred to, exhibited any taste for experimenting; and if so, state what, if any, instruments he had with which he was experimenting at or about that time.

A. Yes, sir; he had been working previous to that time in photography; he also had patented, previous to this, a lounge. I believe he has always been experimenting on something for the last sixteen years. The only instruments I knew him having there was a small magnet, a little cup, a battery, I believe they call them, and some wire. He had chemicals of different things, with which he was experimenting in his photography. That is all that I know of.

9th Q. Did you ever, at any time, and when for the first time, know of the transmission and reproduction of sounds, telegraphically, where and under what circumstance, and by whom were such results produced.

A. Yes, sir; I heard sounds transmitted over the wire at No. 72 Warren avenue, in the spring of 1875, by Mr. McDonough. The circumstances were these: I arrived home in the fore part of June, I think it was about the 11th or 12th, I am not positive as to dates. I found wires running down the stairway of his room into the back parlor. I asked Mr. McDonough what it was. He told me that he was experimenting in getting sounds over the wire.

I saw those for three or four days. I don't recollect for how long they remained up there. I could hear a sound when they were singing below, but that was all. I paid very little attention to it at that time.

10th Q. Where were you when you heard sounds when they were singing—in what part of the house, and what instrument, if any, did you listen at?

A. I was in his room, second floor front room. It was a couple of small tin instruments covered with some skin of some kind, thin membrane.

2537

11th Q. Were there two of the tin instruments covered with skin or membrane in the same room in which you were listening?

A. No, sir; not when I heard them.

12th Q. Can you describe the instrumentalities or devices made use of by Mr. McDonough at the time you heard the sound referred to by you, where the instruments were situated in the house, and how connected?

A. I don't think I can, only in a general way. As nearly as I can recollect there was one small tin instrument in his room, and the other one he would remove from one room to another just for convenience. The one that they sang on to they would move around. There was a wire attached to the one and attached to a battery that was in his room. I don't recollect of the battery being in his room; it was generally sitting by the one they sang by.

13th Q. Can you give a more particular description of the instrument that they sung at or onto, how was it constructed?

A. I'll try; as near as I can recollect it was a tin, I should say about six inches high, by about four or five inches across; it was covered with thin membrane on top; it had on the top of it (the one I am describing), I think, a small piece of metal, the wires were attached to this, just what they were attached to I cannot describe, for I don't recollect. It had a needle, or something like a needle, with a piece of bright substance, I don't know what it was, whether it was tin foil or a piece of tin; that was connected with a smaller wire to a larger wire that was on the tin that they sung on to.

Those wires were connected with a magnet that stood in front of another similar tin; the other tin stood horizontal, it did not sit upright; when they sung on the lower one, the vibrations made it so you could hear a sound in the upper one.

14th Q. What was the kind or character of the sound that you heard from the upper tin when they sung on the lower one?

A. It was a general humming noise; I heard no particular sound, more than a general humming noise; I listened very little to it.

JANUARY 25, 1881, 12.30 o'clock P. M.

Examination adjourned to 2 o'clock P. M.

F. A. HERRING,
Notary Public.

JANUARY 25, 1881, 2 o'clock P. M.

Examination resumed, same parties being present.

F. A. HERRING,
Notary Public.

15th Q. State whether or not Mr. McDonough made any changes in the instruments you have described, and if so, what changes and when?

A. Yes, I found some changes; as to when he made them, I don't know. When I first saw any changes, it was on my return home, some time in the latter part of June, 1875. I then found some changes in the former instrument I have described. I found he had substituted an iron hoop covered with a thin membrane. One of them had two pieces of metal on it fastened to the membrane, and a screw running down through the centre of it. I suppose it was a screw, it appeared to hold it to its place. The pieces that were fastened on to the membrane was a little piece turned up at the end, extended above, to which was attached a small wire to each one of those pieces. There were two small pieces, you must recollect. The other membrane was similar in size and appearances, the other hoop, I should say; it was a piece of metal of some kind (I don't know what it was) glued or pasted in the centre of it. The magnet was placed behind the membrane close to that piece of metal. That is the general description of the machine, as near as I can recollect.

16th Q. Please look at the instruments now shown you, marked respectively, "McDonough Transmitter, Exhibit No. 3," and "McDonough Receiver, Exhibit No. 4," and state how they compare with the instruments as you saw then changed on your return home in the latter part of June, 1875?

A. I should take them to be substantially the same.

17th Q. Please state where the instruments, transmitter and receiver, were located, respectively, in your house at that time?

A. This (pointing to transmitter No. 3) was located in the back parlor of the first floor, the other was in the front room upstairs.

18th Q. How were they connected together?

A. There were large wires attached to those small ones on No. 3. There were some batteries setting by the side of this one, No. 4, and the wire extended up the stairs in connection with No. 4. Where they were attached or how they were attached, I don't know.

19th Q. Were the instrumentalities or devices, as last described by you, operated by Mr. McDonough in your presence or with your assistance; if so, state when, where and how, and what were the results obtained?

A. Yes, sir; they were in my presence and with my assistance both. It was in the latter part of June, the exact date I can't recollect, 1875, at 72 Warren avenue, Chicago. I asked Mr. McDonough what results he was getting. He told me he was pretty well satisfied. I requested him to let me listen in order to hear whether I could hear anything or not. I listened at it. At first I heard nothing. I concluded that I was a little too far from the machine. By getting very close to it I could hear singing. I was able to determine what tune he was singing. I also was enabled to catch now and then a word, that is all.

20th Q. Was your hearing good or bad at that time?

A. My hearing was not good at that time, what I would consider good.

21st Q. In what room were you at the time that you listened as you have stated, and in what room was Mr. McDonough at the time he was singing?

A. I was in the front room over the parlor, Mr. McDonough's room, and Mr. McDonough was in the back parlor, down below.

22d Q. State any fact or circumstance that enables you to fix the date of the results produced by the instruments you have described in the latter part of June, 1875?

A. I left home about the 11th or 12th of June on business. I returned the latter part of June, I think the last week in June. I left home again, I think, on the 3d July, for Michigan. I didn't return for several days.

Mr. McDonough also left home and spent the fourth of July away. I have no recollection of meeting Mr. McDonough at home for some weeks after the fourth of July. Those are the principal facts that I have that impress it on my mind that it was the latter part of June.

Mr. McDonough left home again about the 12th or 15th of July, to take a vacation for his health. He was gone some five or six weeks, as nigh as I can recollect, so I have no recollection of Mr. McDonough experimenting until along some time in the fall, as he was away from home.

23d Q. Can you state positively that the operation of the instruments, and the results produced thereby, as you have described, oc-

curred prior to your going to Michigan on the 3d day of July, A. D. 1875?

A. Yes, sir.

24th Q. At the dates last spoken of by you, what was the nature of your business, and was it such as to take you away from home frequently or much of your time?

A. I was traveling and selling goods for our house. I was away the bigger part of the time during that year, and the years previous to those dates, and I might state that I traveled the bigger part of the time while I remained in business.

25th Q. During the time that you resided in the Warren avenue house, and in the months of May, June and July, 1875, who composed the members of your family?

A. Myself, my wife, Mrs. Wilsey, Mr. McDonough, Mr. Eastman and my daughter Mrs. Eastman, and John E. McDonough.

Cross-examination waived by counsel for Bell and by counsel for Gray.

JEREMIAH E. WILSEY.

Subscribed and sworn to before me this 25th day of January, A. D. 1881.

[SEAL.] FREDERICK A. HERRING,
Notary Public.

JOHN E. MCDONOUGH, being first duly sworn, does depose and say, in answer to interrogatories proposed to him by N. C. Gridley, Esq., counsel for James W. McDonough, as follows, viz.:

1st Q. State your name, age, residence and occupation?

A. John E. McDonough; thirty-two years old; residence, Harrison Court Hotel, corner Harrison and Halsted streets, Chicago, and am an upholsterer—foreman for Eastman & Wilkins.

2d Q. Are you a brother of James W. McDonough, one of the parties to this interference?

A. Yes, sir.

3d Q. Where and with whom did you reside during the months of May and June and thereafter during the year 1875?

A. With Mr. Wilsey at No. 72 Warren avenue, Chicago.

4th Q. State when, for the first time, you had knowledge of the transmission and reproduction of articulate sound or speech telegraphically? Where and under what circumstances?

2555

A. It was at 72 Warren avenue in the latter part of June or near the first of July, 1875. I was called to listen by my brother one evening while my mother was singing in the parlor of the house, and I heard the singing, and slapping my brother on the back and saying: "By George, Jimmie, you've got it after all."

5th Q. Where were you, in what part of the house and at wha were you listening?

A. I was in the front room, in the second story of the house, and I was listening at a round ring with some parchment on it.

6th Q. Where was your mother singing at that time?

A. In the story below—in the back parlor.

7th Q. Was the door and transom of the room in which you were at that time open or closed?

A. The door was closed; the transom—I don't know whether it was clearly closed, because the wires run over through the transom.

8th Q. Did you hear the singing you have spoken of through the door or transom, or through the instrument at which you were listening?

A. Through the instrument.

9th Q. Could you hear distinctly through the instrument the song or tune that was being sung, and any words of the song?

A. Yes, sir.

10th Q. Which—either or both?

Objected to as leading.

A. Both.

11th Q. Please state what you heard through the instrument at that time, and all that you heard that you now recollect?

(Objected to that the witness has already answered upon the matter inquired of, and that the inquiry should not be repeated after leading questions have been put.)

A. I heard, "Down come uncle and aunt," "Down come sister Caturah." That's about all that I can recollect at the time, of hearing.

12th Q. Can you describe the construction of the instrument at which you listened, and its connections at that time?

A. Well, I could describe it partly, but I did not know enough about it to give the particulars of its construction.

2556

13th Q. Describe the instrument, so far as you can, and its connections?

A. It was a round band, or bands, with parchment fastened on them, like the parchment on a drum, with a magnet near one of the bands. That's about as near as I could come to it.

14th Q. With what were the wires connected that you say passed through the transom of the door?

A. They were connected with the two machines.

15th Q. Where was the other machine or instrument located?

A. In the back parlor of the first floor.

16th Q. Can you give a description of each construction; if so, describe it?

A. It was a round band with parchment on it; it had a kind of a V-shaped thing on the parchment, or against it—I don't remember, hardly, which. That's about as near as I can describe it.

17th Q. Did you hear the instruments operated more than once, and how soon after the time you have mentioned, if at all?

A. Yes; I have heard them more or less. I don't remember, really, the times and dates.

18th Q. How do you fix the date when you first heard the instruments operated, as you have described, as being in the latter part of June, 1875?

A. By being sick the first week in July, 1875, and being left at the house alone on the fourth of July, 1875.

CROSS-EXAMINATION BY J. J. STORROW, COUNSEL FOR BELL:

19th Cross-Q. The words, "Down come," &c., in your 11 answer, are the words of a song you have often heard your mother sing, are they not?

A. Yes, sir.

20th Cross-Q. Who was in the room with you on the occasion mentioned in your 4th answer?

A. My brother James.

Cross-examination waived by William D. Baldwin, counsel for Gray.

JOHN E. MCDONOUGH.

Subscribed and sworn to before me this 25th day of January, A. D. 1881.

[SEAL.] FREDERICK A. HERRING,
Notary Public.

253

THOMAS B. JEFFERY, being first duly sworn, does depose and say, in answer to interrogatories proposed to him by N. C. Gridley, Esq., counsel for James W. McDonough, as follows, viz. :

1st Q. What is your name, age, residence, and occupation?

A. Thomas B. Jeffery, thirty-six years of age ; residence, Chicago, and occupation a machinist.

2d Q. Do you know James W. McDonough, one of the parties to this interference, and if so, how long have you known him?

A. I do ; since the year 1875.

3d Q. What time in the year 1875 did you become acquainted with him, and under what circumstances?

A. Early in the summer or spring of 1875 he came to me at my place of business and had me make some portions of a model.

4th Q. Describe what you did make for him at that time?

A. I made one or two, or perhaps three, slender wire screws, having two nuts or three nuts on each.

5th Q. Did Mr. McDonough at that time or afterwards inform you what use he intended to make of the wire screws and nuts, or had made of them. If so, when, and what did he say?

A. He told me afterwards, I should judge within six months of the time I had made those pieces, that he had constructed and successfully used a telegraph instrument that conveyed speech, and that pieces that I made were used in constructing it.

(*Answer objected to on the ground that the applicant cannot make his own statements evidence by proving them second-hand.*)

6th Q. Please look at the instrument now shown you, marked "McDonough Transmitter Exhibit No. 3," and state whether you recognize any part of it as having been made by you?

A. I recognize the slender wire screw in the center as being made by me ; to the best of my knowledge, I made pieces like that in the spring of 1875 for Mr. McDonough.

7th Q. Did you make this particular wire screw shown in this instrument with the nuts and stop attached thereto. If so, how lately did you make it?

A. Well, I believe that I made this ; there are no marks about it that I can identify it by, but I recollect making a piece like this within a few months from the present time for Mr. McDonough.

8th Q. How does the wire screw with the nuts and stops attached thereto, as contained in this Exhibit No. 3, compare with those in

its construction that you made for Mr. McDonough in the spring or early summer of 1875?

A. The construction of this and the other referred to is the same, with the exception that the first made were much lighter than this in weight, the nuts being a good deal smaller.

CROSS-EXAMINATION BY J. J. STORROW, COUNSEL FOR BELL:

9th Cross-Q. Did you in 1875 see the model which the screws you made went into?

A. I did not.

Cross-examination by counsel for Gray waived by William D. Baldwin, Esq.

THOMAS B. JEFFERY.

Subscribed and sworn to before me this 25th day of January, A. D. 1881.

FREDERICK A. HERRING,
[SEAL.] Notary Public.

4.45 P. M., January 25, 1881.

Examination adjourned to 9.30 o'clock A. M. January 26, 1881, at the same place.

F. A. HERRING,
Notary Public.

JANUARY 26, 1881, 9.30 A. M.

Examination resumed at same place, the same parties being present.

F. A. HERRING,
Notary Public.

CALVIN COBB, being first duly sworn, does depose and say, in answer to interrogatories proposed to him by N. C. Gridley, Esq., counsel for James W. McDonough, as follows, viz.:

1st Question. What is your name, age, residence and occupation?

A. Calvin Cobb; twenty-eight years; Chicago, No. 333 Ohio

2559

street; and my occupation is stationery and fancy goods at No. 29 Washington street, Chicago.

2d Q. How long have you been engaged in the stationery and fancy goods business in Chicago?

A. Since October, 1869.

3d Q. At what place in Chicago were you engaged in that business in 1875?

A. At No. 36 Monroe street.

4th Q. Do you know James W. McDonough, one of the parties to this interference, and how long have you known him?

A. I do know him. I have known him every since I was a boy.

5th Q. State whether or not you had a conversation with Mr. McDonough at any time in reference to the transmission of articulate speech over a wire by means of electricity, and, if so, state when and where that conversation occurred, under what circumstances and what was said by Mr. McDonough and yourself, stating as particularly as you can?

A. I did have such a conversation with him in the store at No. 36 Monroe street, during the month of December before Christmas, 1875; the conversation was started from our having in the store and on the case a toy; I don't remember what they called it; I can tell you what it was; it was two tin tubes, with one end of each covered with a skin, and through which passed a string, connecting the two pieces; I believe it was called "The Lovers' Telegraph;" Mr. McDonough picked up this instrument, and in speaking of its use he mentioned that he had an electric instrument at home with which he could speak from one part of the house, down stairs, to another part upstairs, and, as I understood, removed as far apart as they could be in the house; I don't remember any more than that fact being stated; I can't remember the words; that was the fact that was stated to me.

Objected to on the ground that the applicant cannot prove facts by proving his own statements.

6th Q. Who was present, if any one, at the time you had this conversation with Mr. McDonough?

A. The conversation took place in the store; I cannot state who was present, probably the employees; may be customers that might have been in the store; no one was present and took part in this particular conversation.

2560

7th Q. State whether or not you mentioned or made known what Mr. McDonough had stated to you in this conversation to any person, and how soon thereafter, and to whom?

A. I did mention it within a day or two to my father, Mr. L. N. Cobb.

8th Q. Who was present at the time you mentioned it to your father, and, if you recollect, state what was said to your father?

A. I don't remember.

CROSS-EXAMINATION BY MR. J. J. STORROW, COUNSEL FOR BELL.

9th Cross-Q. Where did you get "The Lover's Telegraph," that you have referred to?

A. The invoice shipped to us from S. Brainard & Sons, from Cleveland, Ohio; they were agents for the manufacturers in Cleveland.

10th Cross-Q. Who were the manufacturers?

A. I think the name was Wetmore & Co., of Cleveland.

11th Cross-Q. When did you receive them?

A. About the first part of December, 1875.

12th Cross-Q. How did you come to order them?

A. I think they were sent to us on sale, without orders.

13th Cross-Q. Had you ever seen anything of the kind before they were sent to you?

A. No, sir.

14th Cross-Q. How soon after you received them did they begin to be prominently sold on the streets?

A. I think over a year.

15th Cross-Q. How soon after you received them did they begin to be common in other shops?

A. The following October, I believe.

16th Cross-Q. What enables you to fix the following autumn and winter as the time when they began to be common?

A. It is my impression, merely, that it was some considerable time after we received them, and from conversation with wholesale toy houses, to whom we offered them for sale, who stated that it was too late that season to do anything with them, giving me the impression that they would have them the following year.

17th Cross-Q. Do you think there were any other houses in Chicago besides your own that had them in December, 1875, and January, 1876?

A. I think there may have been.

18 Cross-Q. Did you know of any for sale anywhere else; if so, where?

A. I did not.

19th Cross-Q. Did you, during those two months, furnish any for sale, about the streets or in the retail shops; and if so, about how many?

A. We did not furnish any for sale about the streets; I could not state that we did not furnish them to retail shops.

20th Cross-Q. Please to tell me about how many you sold during the winter of 1875–'76?

A. I do not remember; I think less than a hundred; I think it was quite a few.

21st Cross-Q. I understand from your testimony that the manufacturers got them out a little too late to get into the Christmas trade, and that so far as Chicago was concerned, they didn't sell much till the holiday trade for the next year came around; is that about the substance of it?

A. They did get them out too late for the jobbing holiday trade; I don't know how well they sold the following year.

22d Cross-Q. Do you know of anybody except Wetmore & Co. that manufactured them during the winter of 1875–'76?

A. I Do not.

Cross-examination waived by Mr. Wm. D. Baldwin, counsel for Gray.

CALVIN COBB.

Subscribed and sworn to before me this 26th day of January, A. D. 1881.

[SEAL.] FREDERICK A. HERRING,
Notary Public.

MR. JAMES W. MCDONOUGH, being first duly sworn, says:

That I expected to call Samuel G. Wilkins as a witness in my behalf, but that said Wilkins is now absent from Chicago, in St. Louis; that from conversations with said Wilkins, I know that he will testify that he visited me at my residence, No. 72 Warren avenue, Chicago, for the first time, in the month of September, A. D. 1875; that he was in my room and saw various electrical instruments, consisting of diaphragms, magnets and batteries and wires; that he asked me what those instruments were, and that I informed him

that they were for sending speech through wires by electricity, and I informed him that I had successfully operated them.

Mr. Wilkins is of the firm of Eastman & Wilkins.

JAMES W. MCDONOUGH.

Subscribed and sworn to before this 26th day of January, A. D. 1881.

FREDERICK A. HERRING,
Notary Public.

[SEAL.]

It is admitted by counsel for Bell and counsel for Gray that the witness Wilkins, if called, would testify as above stated by Mr. McDonough, and it is agreed that the foregoing sworn statement by Mr. McDonough may be read in lieu of the deposition of the said Wilkins, subject to all legal objections as to competency and effect.

It is also agreed that the testimony and exhibits may remain in the custody of the notary until the hearing.

Commision closed.

F. A. HERRING,
Notary Public.

STATE OF ILLINOIS, } ss.:
County of Cook, }

I, FREDERICK A. HERRING, a Notary Public in and for the said County of Cook, and State of Illinois, do hereby certify that the foregoing depositions of James W. McDonough, Frank L. Eastman, Jeremiah E. Wilsey, John E. McDonough, Thomas B. Jeffery, and Calvin Cobb, were taken on behalf of James W. McDonough, in pursuance of the notices hereto annexed, before me at the office of Gridley & Co., room No. 7, No. 135 South Clark street, in the City of Chicago, State of Illinois, on the twentieth (20th), twenty-first (21st), twenty-second (22d), twenty-fourth (24th), twenty-fifth (25th) and twenty-sixth (26th) days of January, A. D. 1881. That each of the said witnesses was by me duly sworn to tell the truth, the whole truth, and nothing but the truth, before the commencement of this testimony; that the testimony of each of the said witnesses was written out by myself, and subscribed and duly sworn to by each witness respectively; that Elisha Gray appeared by his counsel, Wm. D. Baldwin, Esq., and A. G. Bell by his counsel, J. J. Storrow,

Esq.; that George B. Richmond, A. E. Dolbear, T. A. Edison, and E. Berliner were not present, either in person or by counsel; that the said testimony was taken at the place aforesaid, and was commenced at ten (10) o'clock, A. M., on the said 20th day of January, A. D. 1881, was continued from day to day pursuant to adjournment, and was concluded on the said 26th day of January, A. D. 1881; that I am not connected by blood or marriage with either of the said parties, nor interested, directly or indirectly, in the matter in controversey.

In testimony thereof, I have hereunto set my hand and affixed my seal of office in Chicago, in said County of Cook and State of Illinois, this 26th day of January, A. D. 1881.

FREDERICK A. HERRING,
Notary Public.

[SEAL.]

(No. 56.) Exhibit Stipulation of Parties.

2564

J. A. Welch, Special Examiner, May 14, 1884.

(Introduced in Record, page 13.)

CIRCUIT COURT OF THE UNITED STATES,

SOUTHERN DISTRICT OF NEW YORK.

[IN EQUITY.]

AMERICAN BELL TELEPHONE COMPANY ET AL.

AGAINST

MOLECULAR TELEPHONE COMPANY ET AL.

STIPULATION.

It is hereby stipulated and agreed by and between the respective parties to the above-entitled cause, as follows, to wit:

1. The defendants herein may put in evidence the copy of the depositions of William M. Goodridge and Elisha Gray, respectively, and of the documentary exhibits referred to therein contained in the printed record of the case of Bell Telephone Company *et al.* vs. Peter A. Dowd, formerly pending in the Circuit Court of the United States, within the District of Massachusetts, and the complainants herein may put in evidence the copy of any other deposition or depositions, and of the documentary exhibits referred to therein contained in the same printed record, and relating to or bearing upon the testimony of the said William M. Goodridge and Elisha Gray, and such copies so put in evidence shall have the same force and effect as if the said depositions had been originally taken, sworn to and filed in this cause.

2. The copies or translations of the publications designated upon pages 529, 530 and 530½, and printed upon pages 531 to 623 inclu-

sive, of the record in the case of American Bell Telephone Company vs. Amos E. Dolbear *et al.*, formerly pending in the Circuit Court of the United States, within the District of Massachusetts, may also be put in evidence in this cause with the same force and effect as though the originals had been produced and duly proved herein. The copies of such of the said publications as are mentioned in the defendant's answer in this cause shall be deemed to have been put in evidence by the defendants, and the remainder shall be deemed to have been put in evidence by the complainants, but either party shall be at liberty to take further evidence, if need be, in relation to the meaning of the originals or any part thereof in a foreign language from which the said translations have been made.

3. The defendants and the complainants herein respectively may also put in evidence copies of any caveats, patents, applications for patents, or other documentary matter not embraced in the publications already hereinbefore referred to, contained in the printed records of the following cases formerly pending in the Circuit Court of the United States, within the District of Massachusetts, to wit, Bell Telephone Company *et al.* vs. Peter A. Dowd, American Bell Telephone Company vs. Albert Spencer *et al.*, and American Bell Telephone Company vs. Amos E. Dolbear *et al.*, and such copies, so put in evidence, shall have the same force and effect in this cause as though the originals thereof had been produced and duly proved herein.

4. The defendants herein may also put in evidence copies duly certified from the Patent Office of the testimony taken on behalf of James W. McDonough, and of the documents, drawings and models referred to therein as exhibits in the interference designated "G" declared March 26, 1878, between him, Elisha Gray, Amos E. Dolbear, Alexander Graham Bell, George B. Richmond, Thomas A. Edison and Emile Berliner, and such copies so put in evidence shall have the same force and effect as if the said testimony had been originally taken, sworn to and filed in this cause.

5. All the evidence taken and hereafter to be taken in the case of the American Bell Telephone Company *et al.* vs. The People's Telephone Company *et al.*, pending in the Circuit Court of the United States, within the Southern District of New York, shall be considered and treated as if the evidence for complainants and defendants respectively in that cause had been taken, sworn to and filed on behalf of the complainants and defendants respectively in

this cause, and the printed record in that cause shall constitute part of the record upon which this cause shall be presented for judicial determination at final hearing.

GEORGE L. ROBERTS,
Of Counsel for Complainants.
MILLER, PECKHAM & DIXON,
Defendant's Attorneys.

(No. 57.) Defendants' Exhibit, Gray's Patent of Feb. 15, 1876.

J. A. W. Sp. Examr. May 20, 1884.

(Introduced in Record, p. 13.)

UNITED STATES PATENT OFFICE.

ELISHA GRAY, OF CHICAGO, ILLINOIS.

Improvement in Electro-Harmonic Telegraphs.

Specification forming part of Letters Patent No. 173,618, dated February 15, 1876; application filed January 27, 1876.

To all whom it may concern:

Be it known that I, Elisha Gray, of Chicago, in the County of Cook, and State of Illinois, have invented a new and useful art of producing musical impressions or sounds and transmitting said sounds telegraphically, as well as improved apparatus for so transmitting said sounds, of which the following is a specification.

In Letters Patent of the United States, granted me July 27, 1875, and numbered, respectively, 166,095 and 166,096, I have shown and described methods of transmitting musical impressions or sounds telegraphically.

My present invention relates to means whereby tunes may be played by a single operator, and reproduced if desired, at a distant station by apparatus described in the patents above mentioned, or in other ways, for which applications for Letters Patent filed by me and now pending.

My invention primarily consists in a novel art of producing musical impressions or sounds by means of a series of properly tuned vibrating reeds or bars thrown into action by means of a series of keys opening or closing electric circuits. It also consists in a novel art of transmitting tunes so produced through an electric circuit and reproducing them at the receiving end of the line. My improvements further consist in novel apparatus for the production and transmission of such tunes. The subject-matter claimed will hereinafter specifically be designated.

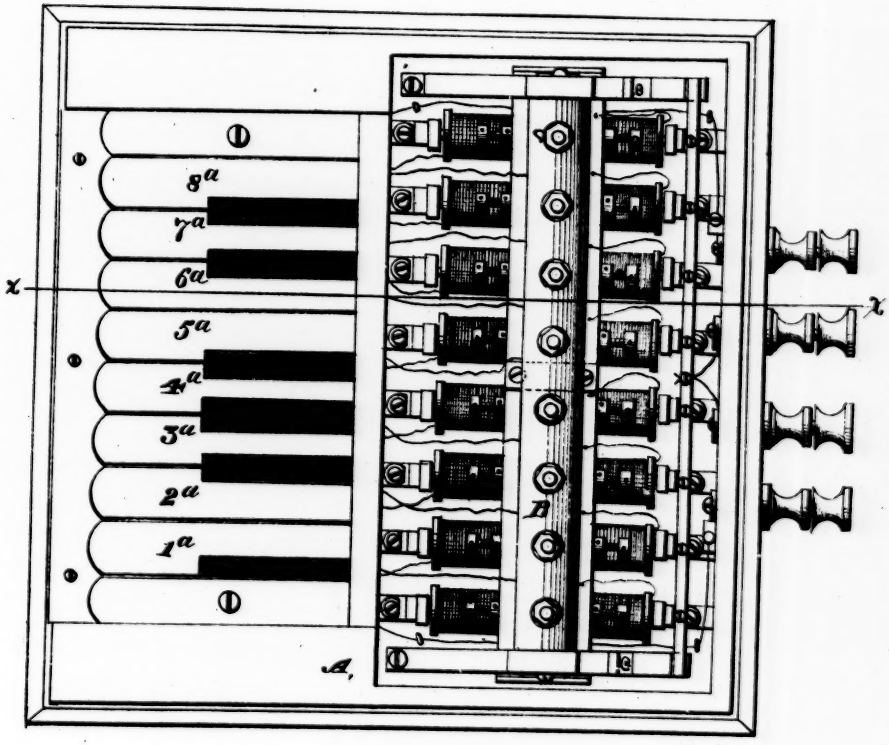
3 Sheets—Sheet 1.

E. GRAY.

ELECTRO-HARMONIC TELEGRAPH.

No. 173,618. Patented Feb. 15, 1876.

Fig. 1.



2

3 Sheets—Sheet 2.

E. GRAY.

ELECTRO-HARMONIC TELEGRAPH.

No. 173,618. Patented Feb. 15, 1876.

Fig. 2.

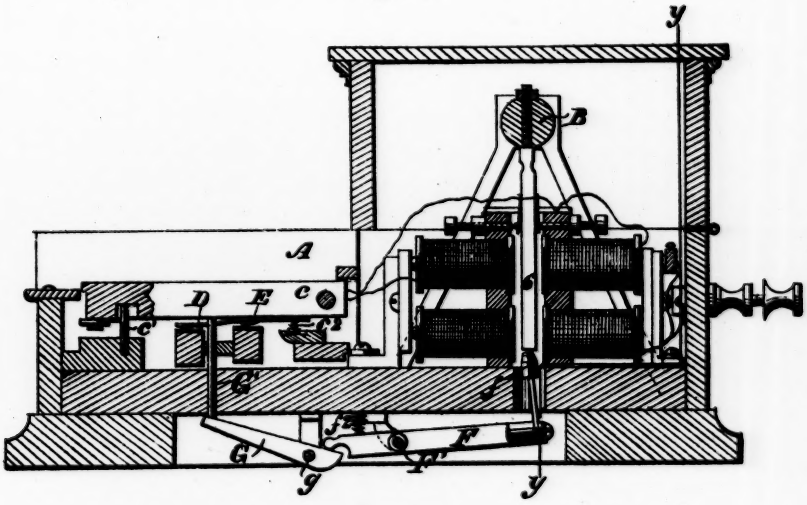
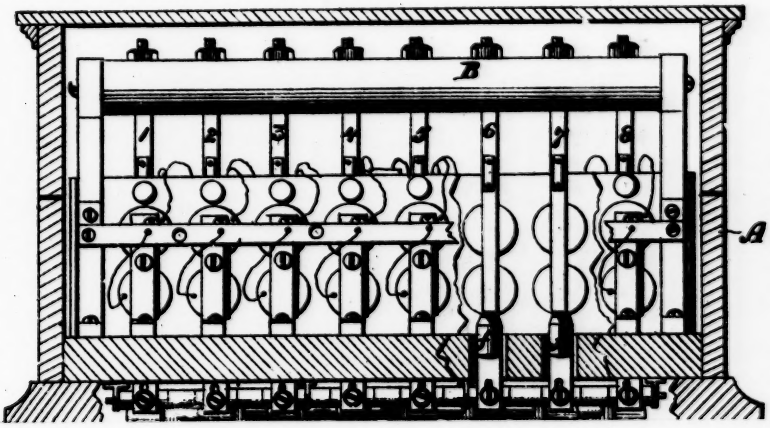


Fig. 3.



3 Sheets—Sheet 3.

E. GRAY.

ELECTRO-HARMONIC TELEGRAPH.

No. 173,618. Patented Feb. 15, 1876

Fig. 4.

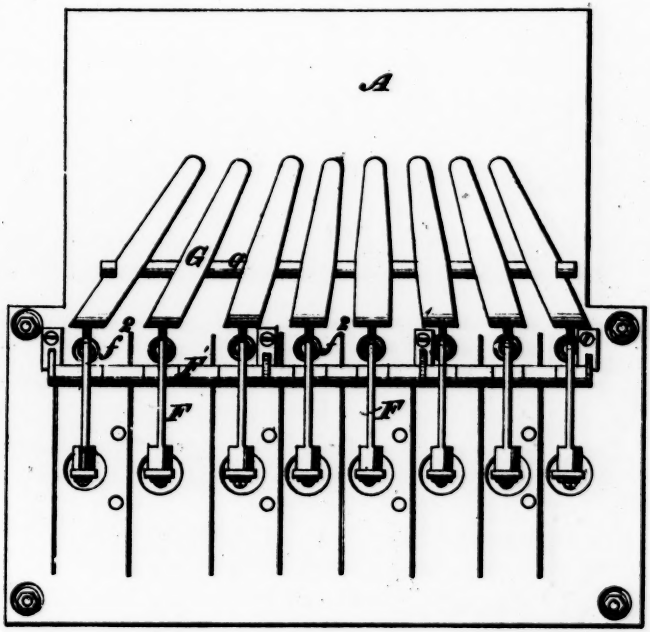


Fig. 5.

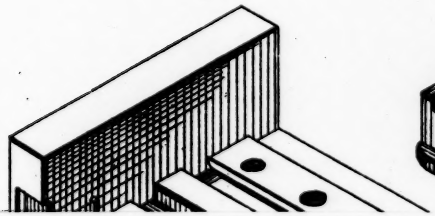
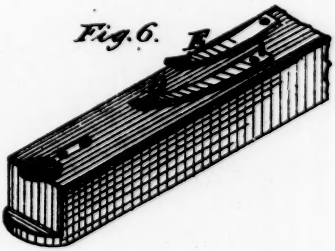


Fig. 6.



3 Sheets—Sheet 3.

E. GRAY.

ELECTRO-HARMONIC TELEGRAPH.

No. 173,618. Patented Feb. 15, 1876

Fig. 4.

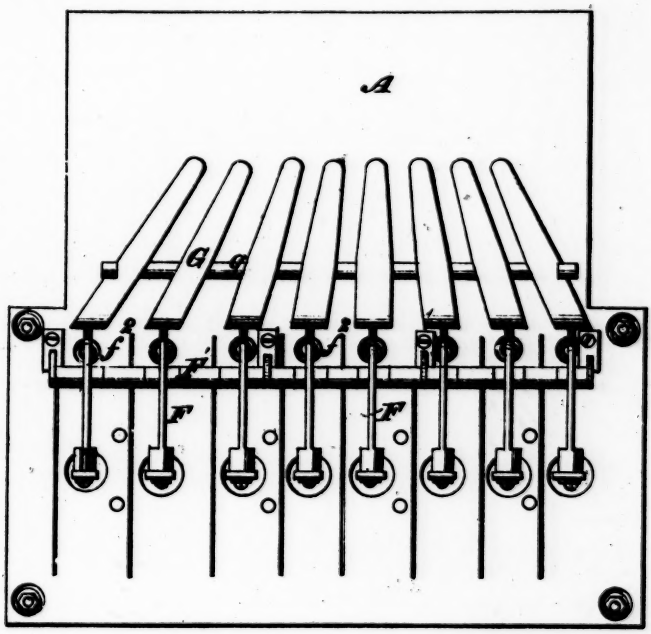


Fig. 5.

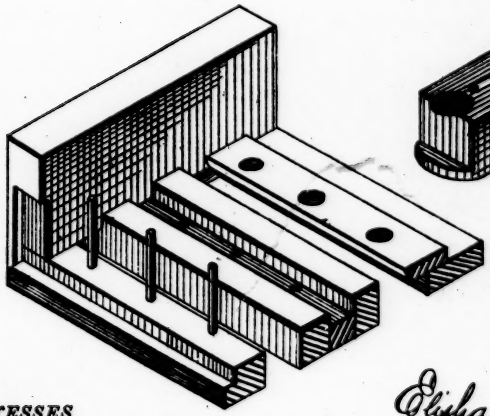
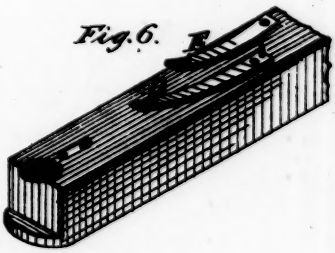


Fig. 6.



WITNESSES

Wm. J. Payton

F. Fish

Elisha Gray INVENTOR

By Wm. D. Baldwin

his Attorney

In the accompanying drawings Figure 1 shows a plan or top view of so much only of my improved apparatus as is necessary to illustrate the subject matter herein claimed; Fig. 2, a vertical transverse section there through on the line $x\,x$ of Fig. 1; Fig. 3, a vertical transverse section there through on the line $y\,y$ of Fig. 2; Fig. 4, a bottom plan view of the instrument; and Figs. 5 and 6 represent views in perspective of certain details of the mechanism.

The drawings show an electrical organ of a single octave embodying my improvements in the best way now known to me; obviously, however, the number of the keys may be increased, and the details of construction of the instrument may be varied in many well known ways without departing from the principle of my invention.

The mechanism is shown as inclosed in a box or frame A. A series of vibrating reeds or electrotomes, 1, 2, 3, 4, 5, 6, 7, 8, each tuned to produce a note of different pitch, is shown as mounted in a bar, B, secured upon a stout frame.

The method of constructing and operating these reeds is fully shown and described in Letters Patent No. 165,728, granted to me July 20, 1875, and need not, therefore, be recapitulated here. Each vibrating reed forms part of an electric circuit which is opened and closed by its respective key, 1^a, 2^a, 3^a, 4^a, 5^a, 6^a, 7^a, 8^a, which takes the place of an ordinary Morse key. Each key works on a pivot c (see Fig. 2), and has a guide pin, c', to keep it steady. A spiral spring, c^2, holds the key up and keeps the circuits normally open. When a key is depressed, both the main and local circuits are closed by springs, D, E, on the under side of the key, which form part of the circuit. The keys are in other respects like those of an ordinary melodeon.

To counteract the tendency of one reed to be thrown into sympathetic vibration by another when sounded, I mount a series of stops, f, each on its respective lever F, rocking on a pivot F', and provided with a spring f^2, by which each stop is normally pressed against the end of its vibrating reed after the manner of the dampers of a piano. The stop is withdrawn from the reed whenever its key is depressed, by means of a lever, G, rocking on a fulcrum, g, and actuated by a pin, G', on the key. The vibration of the reed is thus instantly stopped as its circuit opens; and is promptly released the moment before the circuit closes to throw it into action again. The method of running the main and local circuits in this instance is similar to that shown in my patent No. 165,728, above mentioned.

By the mechanism above described the operator is enabled to

play any desired tune, which will be audible at the spot where played and which may be reproduced audibly at a distant station by means of the mechanism described in the letters patent of July 27, 1875, hereinbefore mentioned, as well as by other mechanism which forms the subject-matter of applications for letters patent filed by me February 23, 1875, and January 8, 1876.

I claim as my invention:

1. The improvement in the art of producing musical impressions or sounds telegraphically, hereinbefore set forth, which consists in controlling a series of automatically and electrically vibrated reeds, producing tones of different pitch, by a series of keys arranged organ-fashion and adapted for manipulation by a single operator.

2. The improvement in the art of producing and transmitting tunes telegraphically, which consists in controlling a series of automatically and electrically vibrated reeds producing tones of different pitch, by a series of keys arranged organ-fashion and adapted for manipulation by a single operator, transmitting the tune thus produced through an electric circuit and reproducing it at the receiving end of the line, substantially in the manner described.

3. The combination, substantially as hereinbefore set forth, of a series of electrically vibrated reeds and a corresponding series of keys for controlling them, arranged organ-fashion and adapted for manipulation by a single operator.

4. The combination, substantially as hereinbefore set forth, of the vibrating reeds, the keys, and the stops actuated by the keys to control the reeds.

5. The combination, substantially as hereinbefore set forth, of an electrical organ, an electric circuit, and a receiver in said circuit which reproduces the tune played by the organ.

In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses:

E. C. DAVIDSON,
H. T. EARNEST.

AMERICAN BELL TELEPHONE COMPANY, - 13

play any desired tune, which will be audible at the spot where played and which may be reproduced audibly at a distant station by means of the mechanism described in the letters patent of July 27, 1875, hereinbefore mentioned, as well as by other mechanism which forms the subject-matter of applications for letters patent filed by me February 23, 1875, and January 8, 1876.

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In testimony whereof I have hereunto subscribed my name.

ELISHA GRAY.

Witnesses :

E. C. DAVIDSON,
H. T. EARNEST.

A. G. HOLCOMB.

Telegrrph-Relay Instrument.

No. 28,274. Patented May 15, 1860.

Fig. 2.

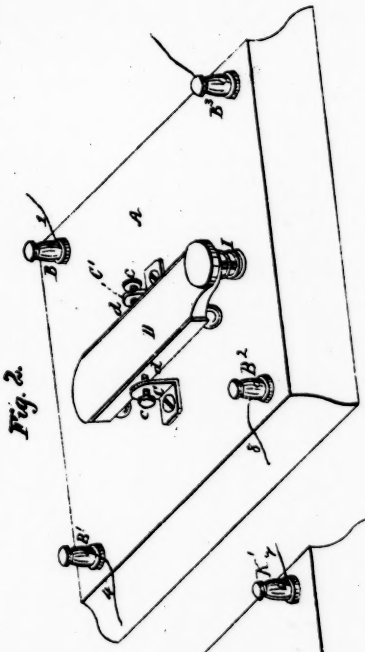


Fig. 3.

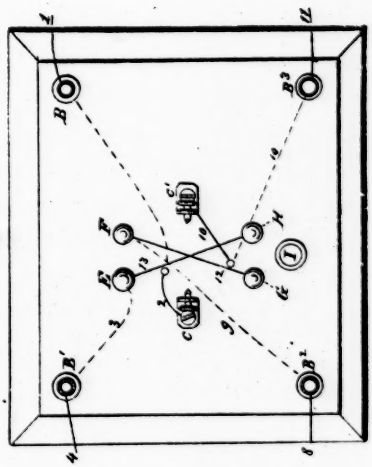


Fig. 1.

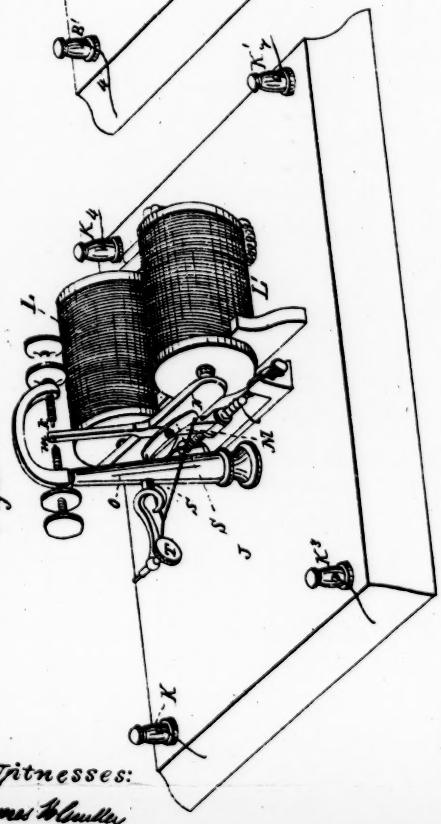
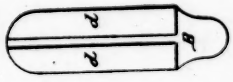


Fig. 4.



Witnesses:

James McCulley

Octavius Knight

Inventor:

A. G. Holcomb

2574

(No. 58.) Defendants' Exhibit, Patent of Alfred G. Holcomb.

J. A. W., Sp. Examiner. May 20, 1884.

(Introduced in Record, p. 13.)

UNITED STATES PATENT OFFICE.

ALFRED G. HOLCOMB OF NEW YORK, N. Y.

Improvement in Telegraphic Instruments.

Specification forming part of Letters Patent No. 28,274, dated May 15, 1860.

To all whom it may concern:

Be it known that I, Alfred G. Holcomb, of the City, County and State of New York, have invented a certain new and useful improvement in electric telegraph apparatus; and I do hereby declare the following to be a full, clear and exact description thereof, reference being had to the accompanying drawings, making part of this specification.

The object of my said invention is to increase the movement of the armature lever by allaying the residual magnetism in the relay magnet after breaking the circuit of the main battery, as hereinafter explained; and the invention further consists in an arrangement for increasing the retentive capacity of the electro magnet.

In the accompanying drawings Fig. 1 is a perspective view of the relay magnet. Fig. 2 is a perspective view of my impr oved manip ulator. Fig. 3 is a plan of the manipulator with the key removed Fig. 4 is an under side view of the key.

A is the base of the manipulator, provided at its four corners with binding-posts B B′ B^2 B^3, and near the center with metallic brackets C C′.

D represents a key, the central position of which is of non-conducting material, separating longitudinally the metallic sides *d d′*.

c c′ are metallic pivots tapped into the brackets C C′. The said pivots form the fulcrum of the key D and afford electrical connection with its respective sides.

E F G H are metallic points projecting upwards from the base A, and each communicating with one end of the respective portions *d* and *d'* of the key as either end is depressed.

I is a spring serving to elevate the front end of the key after depression, and so retain it while at rest.

J is the wooden base of the relay-magnet, provided at its four corners with binding posts K K' K^2 K^3.

The magnet L L' may be of customary construction, but in the present illustration is provided with hollow of bush-cores *l*, of soft iron, interposed between the spools and the steel cores *l'*, by which means a greater amount of residual magnetism is retained.

M is the armature-lever, pivoted at the base in customary manner, and provided near the top with a platina point, *m*. The armature N may be of either steel or soft iron.

O is the metallic standard communicating with the vibrating end of the armature lever by the platina point *o*. *p* is its insulating point or stop. The points *o* and *p* are fixed in the ends of thumb-screws provided with customary check-nuts, as seen in the drawings.

S is the spring employed to draw the armature lever from the magnet when released. The said spring is connected by means of a silken cord, *s*, with a thumb screw, T, to permit the adjustment of its tension. The tension of the said spring is so adjusted as to equal in force the residual magnetism in the cores or armature, and thus hold the armature-lever midway between the points *o* and *p*, when the relay magnet is disconnected from the main battery.

K^2 and K^3 are the binding posts of the positive and negative wires of the local battery, and communicate with the standard O and armature-lever M, respectively, by conducting wires passing beneath the base.

The main conducting wires are arranged and connected with the various parts of the apparatus as shown in the drawings, and as will be more fully understood from the following explanation of the apparatus:

While the apparatus is in its normal position the current passes from the platina or positive pole of the main battery over the wire *l'* to the binding-post B; thence over the wire 2 beneath the base to the bracket C and pivot *c*; thence over the side *d* of the key to the point E; thence over the wire 3 beneath the base of the binding post B', and thence over the line wire 4 to the binding post K of the magnet. It is then conducted by a wire beneath the base to the

coil *l*, traverses this and the coil *l'*, and passes over a wire beneath the base to the binding post K' and earth wire 7.

Fig. 8 is the earth-wire of the main battery, connected to the binding post B^2 of the manipulator, from whence the current passes beneath the base over the wire 9 to the point F; thence over the side *d'* of the key to the pivot *c'* and bracket C'; thence over the wire 10 to the binding post B^3, and thence over the wire 11 to the zinc or negative pole of the main battery.

The effect of the above-described current is to magnetize the cores of the relay magnet and draw the armature lever toward the insulating point *p*, thus breaking the local current. Let the rear end of the key D be now elevated from the points E and F, the circuit of the main battery will be broken and the magnetism in the cores being insufficient to hold the armature lever in contact with the insulating point, it will be drawn by the spring S to its point of equilibrium between the points *o* and *p*; but a further depression of the front end of the key, bringing it in contact with the points G and H, causes the current to flow from the platina pole over the wire 1, post B, wire 2, bracket C, side *d* of key, stud G, wire 12, point F, wire 9, post B^2, wires 8 and 7, post K', coils L' and L, post K, wire 4, post B', wire 3, point E, wire 13, point H, side *d'* of key, bracket C', wire 10, post B^3, and wire 11, to the zinc pole of the main battery, thus reversing the direction of the current through the coils of the relay magnet and allaying its residual magnetism by partially changing its polarity, the effect of which is to enable the spring S to draw the platina point *m* in close contact with the platina point *o*, and thus complete the local circuit.

It will be seen that by the above described arrangement of key, points and wires, a single motion of the key is made to not only break or complete the circuit, as the case may be, but to first break it and then complete it in reverse direction, the effect of which is to greatly increase the variations of the magnet in its active and inactive conditions and correspondingly increase the power exerted upon the armature lever by the magnet and spring, respectively.

It is well known that with the apparatus now in common use the presence of either electricity or moisture in the atmosphere renders it impossible to effect a sufficient movement of the armature to produce intelligible signals. By the use of the reverse current I am enabled, with a battery of a given power, to work effectually with a greater movement of the armature than is otherwise practicable.

It is not necessary that the residual magnetism should be con-

fined to the cores of the electro-magnet. It may be in the armature or cores by a magnet placed in any suitable position.

I claim as new and of my invention herein and desire to secure by letters patent:

1. Producing an additional movement of the armature lever by reversing the electrical current in the coils of the magnet, substantially as set forth.

2. The arrangement of the steel cores l' and iron bush cores l, in combination with the coils of the electro-magnet.

In testimony of which invention I hereunto set my hand.

ALFRED G. HOLCOMB.

Witnesses:

JOHN S. HOLLINGSHEAD,
JAMES H. GRIDLEY.

2578

(No. 59.) Defendants' Exhibit, Patent of William Thomson.

J. A. W. Sp. Examiner, May 20, 1884.

[Introduced in Record, p. 13.]

UNITED STATES PATENT OFFICE.

WILLIAM THOMSON, OF GLASGOW, GREAT BRITAIN.

Improvement in Electric Telegraph Apparatus.

Specification forming part of Letters Patent No. 156,897, dated November 17, 1884; application filed January 6, 1872.

To all whom it may concern:

Be it known that I, SIR WILLIAM THOMSON, Knight, of Glasgow College, Doctor of Laws, and Professor of Natural Philosophy in the University and College of Glasgow, in the Kingdom of Great Britain, a subject of the Queen of Great Britain, have invented or discovered new and useful improvements in Transmitting, Receiving, and Recording Instruments for Electric Telegraph; and I, the said SIR WILLIAM THOMSON, do hereby declare the nature of the said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof, that is to say:

My said invention consists in improvements of and adjuncts to my syphon recorder, whereby it can be used both as a sending and receiving instrument, and is also made more sensitive and effective, more easily adjusted, and more regularly supplied with sparks. The instrument is rendered more sensitive by having each side of the suspended or signal coil in a magnetic field.

Figure 1, sheet 1, shows a front elevation of the suspended coil *a a a a* with a fixed iron core, *b b*, inside it. Fig. 2, sheet 1, shows a side elevation of the same coil *a a* and soft iron core *b b*. Fig. 1, sheet 2, shows a front elevation of the same coil and core, similarly lettered, in their position between the poles *c c* of a powerful electro-magnet. Fig. 2, sheet 2, shows a side elevation of the case A A

fined to the cores of the electro-magnet. It may be in the armature or cores by a magnet placed in any suitable position.

I claim as new and of my invention herein and desire to secure by letters patent:

1. Producing an additional movement of the armature lever by reversing the electrical current in the coils of the magnet, substantially as set forth.

2. The arrangement of the steel cores l' and iron bush cores l, in combination with the coils of the electro-magnet.

In testimony of which invention I hereunto set my hand.

ALFRED G. HOLCOMB.

Witnesses:

JOHN S. HOLLINGSHEAD,
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To all whom it may concern:

Be it known that I, SIR WILLIAM THOMSON, Knight, of Glasgow College, Doctor of Laws, and Professor of Natural Philosophy in the University and College of Glasgow, in the Kingdom of Great Britain, a subject of the Queen of Great Britain, have invented or discovered new and useful improvements in Transmitting, Receiving, and Recording Instruments for Electric Telegraph; and I, the said SIR WILLIAM THOMSON, do hereby declare the nature of the said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof, that is to say:

My said invention consists in improvements of and adjuncts to my syphon recorder, whereby it can be used both as a sending and receiving instrument, and is also made more sensitive and effective, more easily adjusted, and more regularly supplied with sparks. The instrument is rendered more sensitive by having each side of the suspended or signal coil in a magnetic field.

Figure 1, sheet 1, shows a front elevation of the suspended coil *a a a a* with a fixed iron core, *b b*, inside it. Fig. 2, sheet 1, shows a side elevation of the same coil *a a* and soft iron core *b b*. Fig. 1, sheet 2, shows a front elevation of the same coil and core, similarly lettered, in their position between the poles *c c* of a powerful electro-magnet. Fig. 2, sheet 2, shows a side elevation of the case A A

containing the large magnet, only one pole, *c*, of which is visible in this view.

The coil *a a a a* is made in the form of a long rectangle, and is supported at *c c*, so that it is movable about the middle line parallel to the long sides. The space between the iron core and the magnet is as narrow as is consistent with freedom of oscillation for the coil.

By this arrangement I obtain the following advantages: The force with which the coil is deflected by any given current in this arrangement is increased, because by it the short portions only of the coil at the top and bottom are not effectively influenced by the electro-magnetic force. The length of the top and bottom portions of the coil can, by the said arrangement, be greatly reduced, and so the mass and moment of inertia of the signal coil are much diminished.

The instrument is rendered more effective and is more easily adjusted by the application of graduated shunts to the signal coil, to regulate what I designate the damping. This is an effect due to induction between the moving coil and the magnet, and its effect is to diminish or wholly prevent injurious oscillation in the signal coil. One method of producing this effect heretofore adopted consists in applying a shunt to the receiving coil. I now provide a set of shunt coils of graduated resistances with a convenient arrangement, whether by a plug or slide, for applying the desired degree of shunt to the movable coil. By this means the exact amount of damping suitable to each speed of signal can be obtained. This system of graduated shunts is also convenient for assisting in the adjustment of the sensibility of the instrument. These shunts are, for the sake of simplicity, not shown in the drawing, They may be placed inside the case A A, and are to be in electrical connection with the terminal screws *d d'*, shown at Figs. 1 and 2, sheets 1 and 2. The received current enters by one of these screws, *d*, and after flowing through the signal coil *a a*, goes out by the other screw *d'*. A portion of the received current is necessarily diverted through the shunt.

Another method of obtaining the required damping is to construct the signal coil, wholly or in part, of bare wire, the effect being wholly or partially to short circuit the signal coil by contact between successive layers. The advantage gained by this plan is extreme lightness of coil.

The signal coil, with its soft iron core and suspension, is attached

to a removable plate, easily taken out and replaced. This removable plate is shown detached from the instrument at Figs. 1 and 2 of sheet 1, being lettered B B. In Figs. 1 and 2, sheet 2, it is shown in its place. This removable plate B B, together with the soft iron core *b*, suspended coil *a*, connecting fiber *s*, and suspended siphon *m*, may be kept ready in duplicate to replace almost instantly that which has been in use, in case of any accident, such as the clogging of a siphon.

The adjustment of the signal coil is improved by using the torsional elasticity of stretched wires to give it directing force. These wires *e* and *e'* are shown in Figs. 1 and 2, sheet 1. The upper one can be shortened or lengthened by turning the drum *f* and slipping the little brass piece on which it is mounted up or down the slide *f'*, from which it is insulated by the piece of vulcanite *f''*. The lower wire might have a similar adjustment, but I prefer to leave the shortening and lengthening to be done at one end only, and to attach the lower end to a spring *g*, the effect of which is to limit the stress on the stretched wire, and keep it constant.

The directive power is given by the torsional elasticity of the wires *e e'*. The undeflected position of the signal coil is adjusted by turning the drum *h* on its axis. This twists the wires *e e'*, and turns the coil to right or left, as may be desired. Three small adjusting screws, *h' h'*, are provided, by which the wire *e* may be made truly central with the pivot *g'*, Fig. 3, sheet 1, and a second set of three screws, *h''*, is provided, by which the pivot *g'* can be made truly central relatively to the fixed iron core *b b*. With these adjustments the space between *b b* and *c c* can be made much smaller than would be possible without them. The wires *e e'* also serve as electrodes or terminal wires to the signal coil, and are connected by suitable helices *l l* with the insulated terminals *d d'*. I improve the suspension and adjustment of the siphon by carrying it in a similar manner—that is to say, upon a wire stretched in torsion. The long leg of the siphon is lettered *m*, and its short end *n* dips into the reservoir D. The siphon is carried by a little saddle, *n'*, which supports the horizontal limb thereof, and is attached to the stretched wire $o\ o^1$, held tight by strings o^2, which can be turned round, thereby twisting the wire by the torsion heads *p p'*. The brass frame $q\ q^1$ is capable of adjustment by turning on the axis *r*, which is at the same time a pinching screw.

The whole system $q\ q^1$, siphon *m m'*, and stretched wire $o\ o^1$, can be moved in or out relatively to the plate B B by slipping

AMERICAN BELL TELEPHONE COMPANY, - 13 -

2581

it between the nut r and the support r', but firmly held by the screw r and nut when the adjustment is complete. The fibre joining the siphon and signal-coil is lettered s, Fig. 2, sheet 1.

The instrument is adjusted as follows: Lengthen or shorten the wires $e\,e'$, to give the required rapidity of oscillation; make the wire e central with the point g', make the point g' central with the iron core $b\,b$; turn the torsion head h in such a direction as would tighten the fibre s; turn the torsion heads $p\,p'$ in such a direction as will tighten the fibre s; also move out the frame q so much as will tighten s sufficiently to bring back the siphon to a mean vertical position, and the coil $a\,a$ to the central position shown in the drawing. If the fibre s brings the siphon back to the vertical before bringing the coil $a\,a\,a\,a$ to its central position, undo a little of the twist given by the torsion head h, and *vice versa*. I sometimes use a fine glass tube instead of a siphon, fixing the upper end to the ink-bottle, and making the tube of such a shape that its marking arm can spring, by torsional elasticity or otherwise, so as to follow the oscillations of the signal coil with sufficient freedom. In this case I keep that member of the fine tube next the ink-bottle stretched in a straight line by the tension of a stout fibre connected to it and extending from the point where the tube is bent at right angles to form the marking arm. This arrangement is shown in side elevation at Fig. 4, sheet 1, and in front elevation at Fig. 5, sheet 1, where A represents the ink-bottle: B, the fine glass tube of which b is the marking-point: c the portion which springs by tortional elasticity, and d the stout fibre coupling the tube to the arm e.

The tube may be fitted to the ink-vessel by a tube of thin sheet India-rubber, or similar material, or the tube may, as shown in the drawing, be rigidly cemented into the ink-bottle, its own flexibility giving sufficient mobility to the outer end.

The fibre connecting the marking arm with the signal coil may, as is shown at Fig. 5^x, be prolonged, and provided with a very light spring of sufficient resilience for the purpose of keeping the connecting fibre tight during all its motions.

I Sometimes give stiffness to the siphon or tube by stays.

If, in any case, the mobility in the plane of the paper is found too free with a round tube, greater rigidity can be given by making the tube of oval section, or other arrangements of a stretched fibre, acting as a stay or stays as shown at Figs. 11, 12, and 13, may be used.

Another method of arranging the marker is shown at Fig 13^x.

a is a fine marking arm, cemented into a somewhat coarser horizontal branch projecting from a glass siphon, *b*. This siphon is supported so as to be capable of turning round its long vertical leg. The mode of support is by two stretched wires or fibres pulling in opposite directions. The axis of motion is in this plan vertical. The fine marking arm is about as fine as a fine sewing-needle. The coarser arm and siphon is of glass tube, just wide enough to let the fine arm slip in.

The fine marking arm may be pulled out in case of choking, and another slipped in and cemented with wax at any moment.

While giving greater effective rigidity in the plane perpendicular to the paper, it will give either unchanged mobility, or less mobility, or greater mobility of the tube parallel to the paper, according as its fixed end is in a certain line perpendicular to the length of the tube, or nearer the outer end, or farther from the outer end. When the single stay is used its fixed end is adjusted to give the desired mobility to the outer end of the tube, and the proper tightness of the stay.

This improvement allows the plane of the arc, along which the marking end of the tube moves in virtue of the signals, to be horizontal instead of vertical, as it necessarily is with the siphon, if of simplest form, and smallest amount of inertia attainable; and it also allows, when desired, the signals to be first shown on the portion of the paper where it is running horizontally.

This improvement further allows ink or other fluid to be forced through the tube by hydrostatic pressure, to clean the tube or to mark paper for signals independently of sparks. In many cases—for instance, in rapid signaling with powerful currents through land-lines—the requisite pressure for good marking, whether with or without electrification of the siphon, may be that due to from one to three or four inches head of the liquid.

In all such cases this pressure is most conveniently obtained by having free communication of air pressure between the atmosphere and the free surface of ink in the ink vessel—that is to say, by having the ink vessel either open or closed by a cover not perfectly air-tight. When greater constant pressure is desired that can be easily thus obtained. I produce the requisite pressure either by gravity acting on a column of mercury, or by air or other fluid pressing on the free surface of the ink, or by a piston or by a flexible part of the ink bottle acted on by force properly applied from without. The column of mercury is preferable in respect of constancy. I also apply hy-

2583

drostatic pressure to free the tube from obstructions. If the tube becomes clogged at any time, so as to impair the marking, the obstruction is often removable by fluid pressure forcing the ink to flow through it. This cannot be done easily for the siphon otherwise than by the operator's sucking the lower end of it by his mouth—a delicate operation, involving the probability of breaking the siphon. With the fixed tube various methods can be adopted, by which it may be cleared with much greater force with perfect safety to the tube, and without any dexterity on the part of the operator.

One of these is as follows: I apply an air syringe of small bore to the upper part of the ink bottle, which, if ordinarily open to the air, is to be closed for the occasion by a proper plug or stop-cock. Any degree of air pressure required is then readily applied to the free surface of the ink.

Another method is by a reservoir of mercury connected by a flexible tube to one branch of a **U** tube, the upper portion of the other branch of which is in hydrostatic communication with the ink vessel, either through the liquid itself, continued to the surface of the mercury, or through a portion of air intervening. A much greater pressure than can be obtained by blowing with the mouth can be easily provided by raising the reservoir of mercury at any time through the spaces of a few inches or feet.

The mercury reservoir may be left ordinarily in such a position as to give the proper pressure for regular marking; but at any time, in case of suspected clogging, for instance, it may be instantly raised or lowered, so as to produce a largely increased or largely diminished pressure.

When mere pressure on the ink will not remove obstructions I force down nitric acid or suck it up from the bottom of the tube from a vessel provided with this object. This is most easily done by applying (with the aid of the apparatus above described) nitric acid to the marking end of the tube, and drawing a very small quantity of that fluid through the tube, either by a syringe acting as a drawing air-pump, or by a mercury vessel lowered several inches below the level of the tube.

I put a counterpoise to the siphon, preferably attached on the aluminium carrier on the side remote from the marking arm of the siphon, to diminish irregular vibrations. This counterpoise, which may be of wax, is attached to the carrier n', so that the centre of inertia of the siphon m and the carrier with counterpoise may lie on the axis round which the whole turns. This has two advantages:

2584

first, diminishing the tendency to irregular vibrations caused by tremors transmitted through the framework, whether from the moving gear or from disturbances in the neighborhood, such as are experienced when the instrument is used in a crowded city, in a factory or at sea; second, checking the disturbance of signals caused by the motions of the ship when the instrument is used at sea.

I conduct away ink flowing from the siphon when not in use by an adjustable vessel or reservoir (not shown in the drawings). In order to admit of the introduction of this reservoir, and for other purposes it is necessary that there should exist an arrangement for drawing back the paper from the siphon point. This arrangement is shown in Fig 1, sheet 2. The paper follows the line I I I I, being drawn only by the roller *t* driven by suitable gear from the prime mover, namely, an electro-magnetic engine hereinafter described. Just before reaching this roller *t* the paper passes over the shield *w*, and this shield can be drawn back or pushed forward by the screw and thread *w'*, which, on being turned, causes the shield *w* to slide backward or forward. This mechanism is shown in enlarged detached views at Figs. 1 and 2, sheet 3. The paper can also be adjusted laterally by moving the whole bracket E E outward and inward on the frame F. This gives an adjustment in a plane at right angles to that in which the head *w'* causes the paper to move.

I also provide against the accumulation of large drops of ink at the end of the siphon or tube, when no signals are being recorded, by keeping the paper moving at a slow speed. I drive the drawing off roller as follows: A small V pulley, 3, Figs. 1 and 2, sheet 2, is placed on the shaft of a prime mover, 2. A belt passing round 3 drives the large pulley 4 on the shaft 5. A belt from a small pulley 6, on the shaft 5, drives the pulley *t'* on the shaft of the paper roller *t*, or instead of this arrangement I prefer to use that shown at Figs. 6 and 7, sheet 3, wherein the paper roller *t* is driven by means of a clutch *q*, and this allows the paper to be moved at a slower rate than obtains with the mechanism previously described. The clutch *q* admits of being thrown back so as to release the shaft on which the roller *t* is fixed by means of a lever, *r*, Figs. 6 and 7, sheet 3, and then becomes engaged with a toothed pinion, q^1, which drives a spur wheel, q^2, on a secondary shaft, q^3, a pinion, q^4, on which again drives a spur wheel, q^5, on the shaft of *t*, which is then driven at a much slower speed. I prefer to let the shaft 5 be entirely supported by two belts, having only lateral guides to keep it in its place. This arrangement diminishes friction, and prevents the

2585

transmission of mechanical vibrations from the prime mover to the paper.

The paper and statical induction apparatus are driven by an electro-magnetic engine of improved construction. (Shown at Figs. 6 and 7, sheet 1.) This engine consists of a series of bars of soft iron, *a a a*, arranged like the staves of a barrel, but separated from one another by insulating material, and successively attracted by the electro-magnet A. The make-and-break apparatus by which the electro-magnet is caused to attract the successive bars or armatures *a a a* at the proper time is shown in detail at Figs. 8, 9, and 10, sheet 1, and its position in relation to the electro-magnetic engine is shown at Figs. 6 and 7 thereof. The circuit of the electro-magnet is complete when contact is made between the platinum knob *c* attached to the spring *d*, and the platinized contact piece *c*, which are at other times insulated from one another by the vulcanite piece *f*. The movable contact piece is a short piece of stout platinum wire *c*, soldered near one end of an approximately straight steel spring *d*. This end of the spring is reduced to a round pin *x*, in line with the middle line of the spring, and projecting to a short distance beyond the platinum contact piece. The other end of the spring is attached to a fixed insulated piece of metal *g*, with which it is in metallic communication, and through which it forms a part of the circuit, which is completed when the movable contact piece *c* is allowed to press on the fixed contact piece *e* by the projecting pin *x*, being let down by the cam A. The line of the spring is parallel to the axis of the electro-magnetic engine, and its plane of motion passes through this axis. The cam lifts the projecting pin *x* to break contact, and leaves it free at the proper times to make contact by its own elastic force. The spring *d*, which is approximately straight, either when making contact, or when lifted through the small space of the cam's action on it, is under considerable elastic strain. When dismounted and allowed to take its unstrained shape it is curved. In this state the curvature ought, if the flexual rigidity of the spring is uniform throughout, to be approximately in simple proportion to length along the curve from the end, which is fixed when the spring is in position. This condition is easily fulfilled with sufficient approximation to accuracy by giving the spring a proper set, so that when mounted it is found to be nearly enough straight, and to press with sufficient force against the fixed contact piece to secure good contacts. This disposition is such that the motion of the spring is in

a plane perpendicular to that of the cam, the form of the spring approximately straight, and the point of pressure of the cam very close to the movable contact piece. A screw *w* is used to lift or lower the spring *d*, and thus adjust the length of contacts. The time when contact is made is adjusted by turning round the cam A on the axis, and fixing it in the required position by set screws *i* and *j*. The bearings of the electro-magnetic engine should be constructed so as to cause very little friction, and I attain this end by supporting the pivots of the main shaft *b b*, Fig. 6, sheet 1, on rollers *d d*. Each pivot is prevented from slipping off the roller by two smooth parallel guides, between which it plays easily. Motion of the shaft in the direction of its axis is checked by two hard plates *x'*, fixed perpendicular to its axis at a distance asunder slightly greater than its length. The anti-friction rollers *d d*, each of one piece of steel, are of the shape shown in the drawings. They are kept in position by end plates similar to those hereinbefore described for the main shaft *b b*. Each of the rollers *d d* dips into an oil vessel, and carries oil round sufficiently to keep its own pivots and the pivots of the main shaft constantly oiled.

The guiding cheeks of the main shaft and the bearings of the anti-friction rollers are so placed that, during the action of the instrument, the pivots of the main shaft press each of them, only on one of these guides and on the anti-friction roller, but with much more force on the anti-friction roller than on the guide. It need press with no more force on the guide than to prevent it from leaving that guide and moving over to the other under the influence of the varying force to which it is subjected through the successive electro-magnetic attractions. I regulate the speed of revolution by adding or subtracting resistance from the circuit of the electro-magnet; and I sometimes diminish the spark at the contact piece *e* by using a permanent shunt, connecting the ends of the electro-magnet's coil.

The induction apparatus is constructed so that the replenisher is alone used and the electrophorous heretofore employed is dispensed with. I use the armatures of my engine disposed as staves of a barrel, *a a a*, Figs. 6 and 7, sheet 1, as part of the carriers of the induction apparatus, the other part being a series of brass strips, *f f f*, Figs. 6 and 7, attached to the soft iron staves.

The action of the replenisher is as follows: E, Figs. 6 and 7, is a plate in connection with the earth. B is an insulated plate, from which the electricity of high potential is taken to the siphon. Four

springs, *g h i k*, the last being shown by a dotted line only, are arranged so as to make the contacts hereinafter described. The carriers *a a a a* are moving in the direction of the arrow 1°.

When a carrier *a* first comes under the cover of the insulated plate B, which is, say, positively electrified, it is electrically connected with plate B by the spring *g*, making contact with the metal bar *a'*, attached to *a*. Any positive electricity on *a* then flies to B 2°. When the same carrier *a* has moved farther, so as to be completely covered by the plate B, the contact with the spring *g* is broken, and a little later a fresh contact made with the spring *h*, and a diametrically-opposite carrier *a* is, by the spring *k*, at the same time joined to the carrier *a* first referred to, and, being covered by the earth-plate E, the said carrier *a* becomed by induction positively electrified, while the opposite carrier is negatively electrified, 3°. After the two contacts with *h* and *k* have been broken the carrier *a*, now negatively charged, is put into connection with the earth, and discharged by the spring *i* 4°. The same carrier is, in its turn, positively charged by the spring *k*.

In place of the electro-magnetic engine hereinbefore described I sometimes employ as my prime mover a magnetic engine of the arrangement illustrated at sheet 7 of the accompanying drawings, whereon Fig. 1 is a section, partly in elevation, thereof; Fig. 2, an elevation of that end marked A, Fig. 1; Fig. 3, an elevation of that end marked B, Fig. 1, while Fig. 4 is a detached view of the vulcanite disk G, showing the arrangement of the carriers *a* situated thereon. This engine consists of one bar or of a series of bars of soft iron compactly packed together, situated in the interior of and extending the full length of the cylindrical casing A, which is attached to the engine shaft B, as shown at Figs. 1 and 2. The casing A is so situated in the interior of a powerful cylindrical compound magnet, C, that as the engine revolves the opposite ends of the soft iron bars contained in the casing A are alternately brought under the influence of the opposite poles of the said magnet C.

The make and break apparatus, by which the magnet is caused to attract the opposite ends of the soft iron bars alternately is more particularly shown at Figs. 1 and 3.

The movable contact pieces by which the current is alternately made and broken consist of a series of springs arranged in two sets, D and E. Each of these sets is arranged after the manner of the teeth of a comb, and is made to bear upon the periphery of the drum F, which is situated upon the engine-shaft B, as shown. At

2388

two points in the periphery of the drum F, diametrically opposite to each other, and in the plane of the soft iron bar, strips of agate or other insulating material are inserted, as shown, which, when brought round by the revolutions of the drum F, so as to be in contact with the springs D and E, thereby break the metallic connection, and therewith the attractive influence of the magnet upon the end of the soft iron bar is reversed.

The induction apparatus is constructed and arranged in the following manner: Upon a vulcanite disk G, the carriers *a a* are arranged as shown at Figs. 1 and 4. The disk G and carriers *a a* are partially inclosed by a metallic casing, but which is insulated from the carriers *a a* by means of a thin vulcanite lining, *b*, as more particularly shown at Fig. 1.

The metallic casing is constructed in two parts, as shown at Fig. 2, one side of which, namely, that marked E^x, is in connection with the earth, while that marked D^x is completely insulated, and from which the electricity to the siphon is conducted, the manner whereby the electricity is drawn from the earth-plate E, and discharged on to the insulated plate B, being in every respect similar to that employed for the same purpose with the electro-magnetic engine hereinbefore described, namely, through the medium of the springs *g*, *h*, *i* and *k*, as arranged and shown at Fig. 2. I used a dry pile, contained in the vulcanite-chamber X, Figs. 1 and 2, sheet 1, and Figs. 1 and 2, sheet 2, to initiate the electrification of the inductor B. I connect the electrified inductor B with the siphon by a metallic conductor, W, Figs. 1 and 2, sheet 2, and a semi-insulating thread, *v*. The conductor W leading from the inductor B rests upon the shaft *u'*, upon which the drum Y is carried.

When the conductor W becomes overcharged with the current, a portion of it may be drawn off by placing the wooden arm W′ in contact with or very close to the little wooden stud *l*, attached to the under side of the conductor, and thus a portion of the current is diverted, the remainder or non-diverted portion passing on constantly by a semi-insulated thread *v*, which can be lengthened or shortened to oppose more or less resistance to the passage of electricity. The mode of attaching, lengthening, or shortening this thread *v* is shown in Figs. 1 and 2, sheet 1, and at Figs. 1 and 2, sheet 2.

The one end of the thread is attached to the metal shaft *u* bearing a vulcanite cylinder F, having a deep screw cut on it. The other end of this thread *v* is attached to a small metal drum Y,

2589

acted on by a spring like that on ordinary pocket measuring tape. By turning the vulcanite drum the thread is wound upon it, and pulled out from the metal drum so as to augment the resistance, as in Wheatston's rheostat. When the vulcanite drum is turned in the other direction, the spring draws the string around the metal drum, and the resistance is diminished. If the smallest resistance thus obtained, when the two drums are conveniently placed, is found to be too small, the part of the thread remaining unwound between the vulcanite drum and the metal shaft of the vulcanite drum may be impregnated with salt, or even replaced by a fine metallic wire. A second thread may similarly be used between the plate B and earth, to draw off an excess of electricity. The speed of the engine, as has been stated above, is regulated by shunts and added resistance. The shunts, where chronometric accuracy is desired, are thrown off and on by a differential motion regulated by a pendulum. Instead of shunts, added resistance might obviously be treated in the same manner.

The mode by which the shunts are thrown off and on is shown in Figs. 1 and 2, sheet 4. The shaft *a* is called the chronometer shaft. It rests on two anti-friction rollers *f* and *g*, attached to one long shaft, *h*, which may be supported on ordinary bearings below it. It bears upon these rollers by two other rollers, *i* and *k*, coaxial with itself.

The roller *i* is rigidly attached to the chronometer shaft. The other roller, *k*, is attached to a tube *l*, mounted on this shaft *a* by means of a collar at one end of the tube, and a bearing at its other end for one terminal pivot of the chronometer-shaft *a*. The four rollers, *f*, *g*, *i* and *k*, are of such dimensions as to give the tube *l* such a differential motion that it goes round somewhat faster than the chronometer shaft. I find that something from five to ten per cent. faster than the chronometer shaft gives good results. A second-tube, *m*, fitting between two collars on the chronometer shaft, is placed close to the tube *l*, and is carried round by two spring clips, *n*, pressing it externally, or other suitable friction gear may be employed. This second tube *m*, when unchecked, is carried round as if rigidly connected with the first tube; but it can be checked with ease, so as to be altogether stopped at any time. When it is released the friction is sufficient to set it very suddenly in motion again with the same speed as the first tube. The second tube *m* carries one or more arms, *o o o*, which act upon a pendulum, *p*, through a pallet or pallets, after the manner of the teeth of a dead-beat escapement wheel, as shown at Fig. 4, sheet 4. They keep the

pendulum *p* vibrating, and at each impact on the dead-face of the pallet the rotation of the tube is checked sufficiently to prevent more than one arm from passing for every period of the pendulum. Thus, if a "half-seconds" pendulum be used—that is to say, a pendulum whose period is one second—and if the second-tube *m* is to turn once round in six seconds, there must be six arms; or, if it turns once round in five seconds, there must be five arms, as shown in the drawing.

These arms might be rigid, like the teeth of an ordinary escapement wheel, so that the arrangement would simply be an escapement wheel loose on the chronometer shaft, and influencing it in the manner described below; but I prefer making the arms elastic, to prevent damage in case of any of them being taken aback by the pallet, and also to regulate the motive force applied to the pendulum by each arm in escaping the pallet.

There may be either two pallets, arranged just like the ordinary anchor of the dead-beat escapement, or there may be only one pallet, one side of the anchor, as it were, being cut away. When only one pallet is used, the plane of motion of the arm may very conveniently be perpendicular to the plane of motion of the pendulum, which gives an arrangement preferable, in point of simplicity, to other more common or obvious transformations of the general plan described above.

Another fixed spring, *s*, is similarly kept in communication with a metal ring, *r*, rigidly attached to the chronometer shaft *a*. The rim of this ring is composed partly of metal and partly of insulating material, as seen in Figs. 1 and 2, sheet 4, and is touched by the spring *t* (Fig. 1, sheet 4), carried by the escapement wheel or tube *m*. By insulating materials properly placed these two springs *s* and *t* are cut off from metallic communication through the moving parts, which have been described, except when the spring *t*, carried by the escapement wheel, is in contact with the metallic part of the rim on which it presses.

One or other of the springs *s* and *t* may be in metallic communication with the chronometer shaft and the two tubes *l* and *m*, but I prefer insulating all the pieces of metal which are in connection with either of the fixed wires by vulcanite or other proper material, so as to prevent metallic communication between them and the shaft and tubes. The two springs *s* and *t* are connected to the two ends of the coil of the driving electro-magnet A, Figs. 6 and 7, sheet 1, by electrodes of proper resistance, to fulfill the following condi-

2591

tion: When the second tube m is in such a position relatively to the main shaft a as to make contact, the coil of the electro-magnet is shunted, so as to reduce the driving power sufficiently for the purpose of regulation. For example, if the resistance in the electrodes and movable contact pieces, which have been described, is infinitely small, the driving power would be altogether stopped when the contact referred to is made; but this would be a more abrupt controlling action than is desirable. In most cases I prefer to arrange so that the resistance in the shunt shall be several times greater than the resistauce of the electro-magnet; and I secure that the controlling action shall be sufficient by adjusting the rate approximately by the method above described. All that is necessary to secure this condition is that. without the regulating shunt, the chronometer-shaft would attain a speed greater than the proper speed, but that when the shunt is applied the power is insufficient to maintain the proper speed.

In connection with my instrument I sometimes employ a chronometer for the purpose of indicating the time at which a message is being transmitted or recorded. The position which the said chronometer occupies in relation to the other parts of the instrument is shown on the general arrangement drawings, Figs. 1 and 2, sheet 2; while its constructive features are more particularly illustrated at Figs. 3, 4 and 5, sheet 3, which are respectively a side elevation, plan, and end elevation thereof.

Under the arrangement shown a pinion a', fixed upon the spindle of the paper roller t, is placed in gear with the first wheel b of the chronometer train, the number of teeth in the wheel and pinion being such that, with the rate at which the pinion a' is driven, the wheel b is caused to make a complete revolution in exactly five minutes. In accordance wherewith its flat face is divided into five equal spaces, numerically marked, as shown at Fig. 3, sheet 3. Coaxial with the wheel b, a pinion d is fixed, which is geared into a wheel e, the number of teeth in the pinion d being, to the number of teeth in the wheel e, on the ratio of one to twelve. The wheel e thus makes a complete revolution in one hour. In like manner a pinion f, upon the same axis as the wheel e, is geared into another wheel g, and the ratio of the number of teeth in their respective circumference being one to twenty-four, the wheel g makes a complete revolution in twenty-four hours.

Upon the flat face of the wheel g a drum, h, is fixed concentric therewith, the outer surface of which is divided into hour units, and

numerically marked in succession, as shown at Fig. 3, sheet 3. Its outer rim *i* is correspondingly divided, and at each division has a type or types situate thereat, indicating numerically the successive hours. As the strip of paper, I, upon which a message is to be recorded, or which may be employed as the medium of transmission, according as the instrument is employed for either sending or receiving signals, is drawn along in contact with the lower surface of the drum *h*, in the direction indicated by the line I, and by the arrows at Fig. 3, each hour in succession is stamped thereon, that being effected by means of a stud *k* attached to the wheel *e*, being at a point in each successive hourly revolution brought into contact with and depressing a lever *l*. Immediately that the stud *k* has passed out of contact with the lever *l* a hammer, *m*, fixed upon the extremity of a lever *n*, is forced upward by means of the resistance of a spring *n'*, so as to strike the paper I against the periphery *i* of the drum *h*, whereby it receives an impression from the type or types situated thereon, the said impression recording numerically the hour of the operation, and each successive hour is similarly recorded, minutes being read off at *x* upon the wheel *b*.

The new instrument sends as well as receives messages. The same motive power and gearing may be used to draw forward punched paper for signaling, and I sometimes use the same strips of paper to send and receive messages, alternative lengths of the paper being punched and plain. The electrical connections are so arranged that the signals sent by the paper are recorded on the same paper. The paper used to send is punched into two or more rows of holes, as hereinafter set forth, and contact made through the holes by dead pressure between two metallic surfaces C and D, and sprigs *x* and *y*, as shown at Figs. 6, 7 and 8, sheet 3. These contacts may be made a little behind the siphon, or elsewhere. A suitable switch is provided for altering the connections from sending to receiving. The same instrument, with the signal-coil sufficiently shunted, records the sent signals. I prefer a simple stout bar, F, Figs. 7 and 8, sheet 3, pressed against contacts, as my switch. I give positive and negative signals by two constant springs, *x* and *y*, only. To do this I keep the two poles of the battery constantly connected with one another through a wire, S, Fig. 8, sheet 3, of sufficient resistance, the middle of this wire being connected with the line, as shown, and the middle of the battery with earth.

The diagram, Fig. 8, sheet 3, shows the proper arrangement of connections for sending and receiving, as above described. The

diagram, Fig. 9, sheet 3, shows the punched paper. The part of the instrument by which the paper is punched contains the following peculiarities:

The paper, which is drawn on by a drum after each perforation, begins to move gradually, and, after attaining a maximum of speed, comes gradually to rest. The power employed to make the perforations and to start the paper may first start a fly-wheel loose on a revolving shaft, but tending to draw it on by friction. I also draw back any slack in the paper behind the drum by a spring or weight. The part of the instrument by which the paper is punched is constructed to suit the Steinheil system, with perforations in two rows. The same plan, with obvious enough changes of detail, is applicable to perforate the paper, for other modes of signaling which may be desired. In any case, I use three levers, which, according to usage, will often be called keys. One of them I call the space-key, another the dot-key, and another the dash-key, the recent submarine usage having applied the name of dots and dashes in submarine signaling to left and right motions of the marker.

The dot-key makes its perforations in the proper line of the dots; the dash-key in that of the dashes. The punches may be rigidly attached to the keys, or they may move in slides, pressed down to cut the paper by the key, and returning by springs. I prefer to connect each punch rigidly with its key. The paper is at rest for the whole time during which the lowest part of any of the punches is below the upper surface of the paper, it being supposed that the punches move downward in cutting. As, however, a detailed description and drawings of the said paper-punching mechanism was deemed objectionable upon the examination of my application, they are not given.

In lieu of arranging the instrument in all respects as hereinbefore described, I prefer to dispense with the glass case in which it is inclosed, and sometimes not to use chronometric contact, and to adopt the general arrangement illustrated at sheet 5 of the drawings. In this arrangement an air turbine, driven from a pulley on the revolving-shaft *b b* of the electro-magnetic engine, is used to drive a current of dried air through the casing E containing the electro-magnetic engine, as well as through the tubular casing B which surrounds the insulating stem bearing the ink-bottle and its connections. The turbine is by preference placed in one side of the casing C, which contains the driving electro-magnet, and the current of air drawn in by its revolution is discharged up through the

floor of the casing E, and in part out through perforations *o* in the shield *p* of the conductor W, as shown, and in part by a pipe *q* leading to the tubular casing B. The air driven through the apparatus may be dried by passing it over sulphuric acid, or other means for depriving air of moisture may be adopted. The result of this application of the turbine is both to prevent rust or shreds from settling on the stems, and to keep them dry. The same tubular arrangement allows air to be occasionally forced through by bellows or a hand fanner, so as to blow away from the case and stems dust which may have accumulated.

Having now described the nature of my said invention and the manner in which the same is or may be used or practically carried into effect, I would observe, in conclusion, that what I consider novel and original and therefore claim as the invention is:

1. The combination and arrangement, substantially as before set forth, of the electro-magnet, the suspended signal coil and the fixed soft iron core for said coil.

2. The combination, substantially as before set forth, of the suspended signal coil, the suspended siphon or marking tube and the connecting fibre, with a removable plate or stock, so that the said coil and marking tube can be readily removed and replaced by others adjusted for use.

3. The combination, substantially as before set forth, of the signal coil with the stretched wires communicated with the insulated terminals, the drum to shorten or lengthen the said wires, and a torsion head to turn the same on their axis, so that the signal coil may be adjusted by the torsional elasticity of the stretched wires, which also act as electrodes.

4. The combination, substantially as before set forth, of the marking tube, the stretched wire that carries it and the torsion-head for turning the said wire.

5. The combination, substantially as before set forth, of the ink reservoir, the marking tube and the suspended signal coil, so that while the said marking tube is fixed to the ink reservoir the outer end of said tube is free to be moved in consonance with the oscillations of the signal-coil.

6. The combination, substantially as before set forth, of the ink reservoir and the device for applying a varying pressure to the surface of the liquid in said reservoir, so that said liquid may be drawn or forced through said tube as desired.

7. The combination, substantially as before set forth, of the working arm of the marking tube with a stay for stiffening it.

8. The combination, substantially as before set forth, of the marking tube with a counterpoise to diminish vibrations.

9. The method, as before set forth, of preventing an accumulation of ink at the point of the marking tube when signals are not being received, by traversing the paper slowly past the said point at such times.

10. The combination, substantially as before set forth, of the plate connected with the earth, the insulated plate, the contact springs, the revolving carriers and the siphon or marking tube.

11. The combination, substantially as before set forth, of the motor and the paper-drawing gear by hanging pulleys so as to diminish vibrations.

12. The combination, substantially as before set forth, of the paper-drawing rollers with a pendulum, so as to control the speed of the former.

13. The combination and arrangement, substantially as before set forth, of the paper-moving mechanism, the chronometer mechanism, and the types of the latter, so that the time is recorded upon the signal-receiving paper.

14. The combination, substantially as before set forth, of the electrified conductor with the siphon or marking tube by an adjustable inductor of very high resistance, whereby any excess of electricity may be drained off.

15. The combination, substantially as before set forth, of the suspended signal coil, the magnet, the inductor, and a dry pile to initiate the electrification of the inductor.

16. The arrangement, in the same machine, of a single motor with the suspended signal coil, the siphon or marking tube, the mechanism for moving the receiving paper, and the mechanism for moving the punched paper, so that the same motive power which produces the electric sparks is employed to move forward the receiving paper and the punched paper for sending signals.

17. The relative arrangement, substantially as before set forth, of the suspended signal coil, the siphon or marking tube, the signal transmitting mechanism, and the paper moving mechanism, so that the same strip of paper may be employed both to receive and to transmit the signals.

18. The relative arrangement, substantially as before set forth, of the suspended signal coil, the siphon or marking tube, the signal-

22 Sheets--Sheet 1.

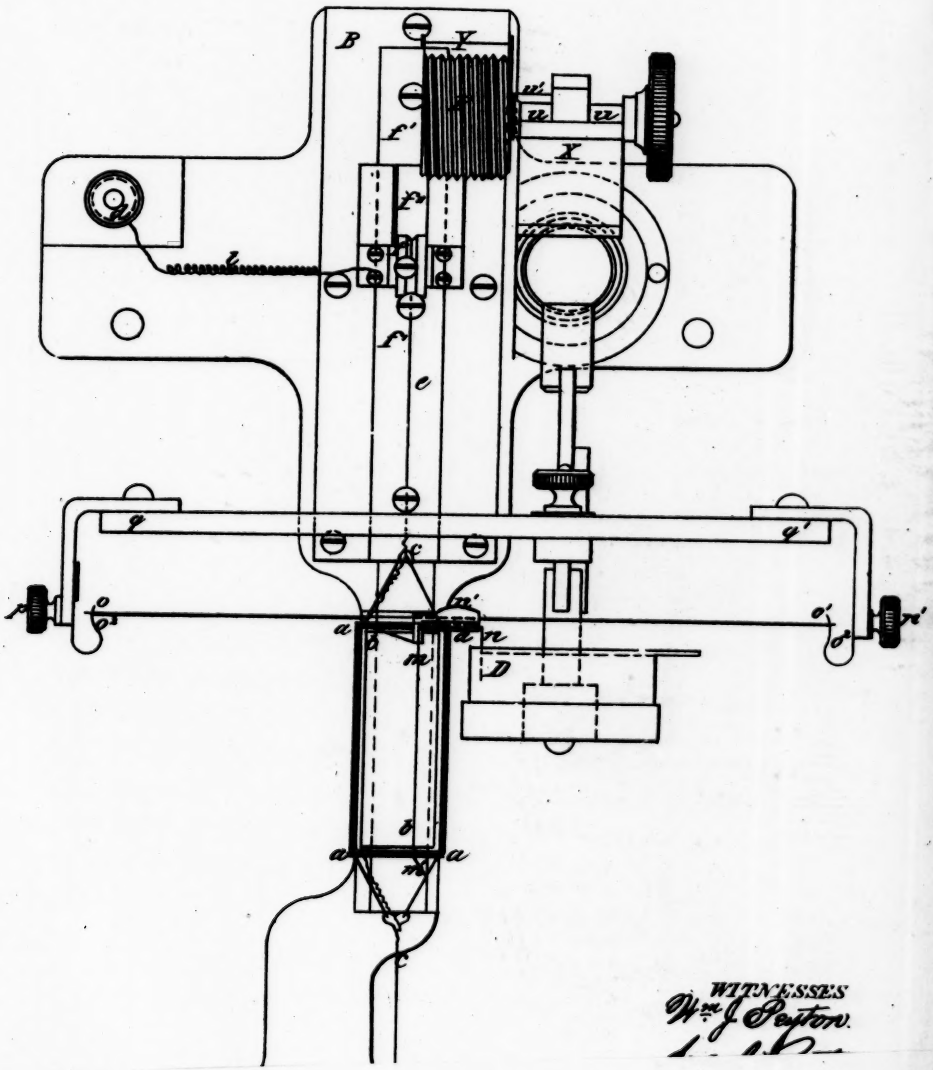
W. THOMSON.

Electric-Telegraph Apparatus.

2596

No. 156,897. Patented Nov. 17, 1874.

Fig. 7 (Sheet 7)



WITNESSES
Wm J. Peyton.

7. The combination, substantially as before set forth, of the working arm of the marking tube with a stay for stiffening it.

8. The combination, substantially as before set forth, of the marking tube with a counterpoise to diminish vibrations.

9. The method, as before set forth, of preventing an accumulation of ink at the point of the marking tube when signals are not being received, by traversing the paper slowly past the said point at such times.

10. The combination, substantially as before set forth, of the plate connected with the earth, the insulated plate, the contact springs, the revolving carriers and the siphon or marking tube.

11. The combination, substantially as before set forth, of the motor and the paper-drawing gear by hanging pulleys so as to diminish vibrations.

12. The combination, substantially as before set forth, of the paper-drawing rollers with a pendulum, so as to control the speed of the former.

13. The combination and arrangement, substantially as before set forth, of the paper-moving mechanism, the chronometer mechanism, and the types of the latter, so that the time is recorded upon the signal-receiving paper.

14. The combination, substantially as before set forth, of the electrified conductor with the siphon or marking tube by an adjustable inductor of very high resistance, whereby any excess of electricity may be drained off.

15. The combination, substantially as before set forth, of the suspended signal coil, the magnet, the inductor, and a dry pile to initiate the electrification of the inductor.

16. The arrangement, in the same machine, of a single motor with the suspended signal coil, the siphon or marking tube, the mechanism for moving the receiving paper, and the mechanism for moving the punched paper, so that the same motive power which produces the electric sparks is employed to move forward the receiving paper and the punched paper for sending signals.

17. The relative arrangement, substantially as before set forth, of the suspended signal coil, the siphon or marking tube, the signal transmitting mechanism, and the paper moving mechanism, so that the same strip of paper may be employed both to receive and to transmit the signals.

18. The relative arrangement, substantially as before set forth, of the suspended signal coil, the siphon or marking tube, the signal-

22 Sheets--Sheet 1.

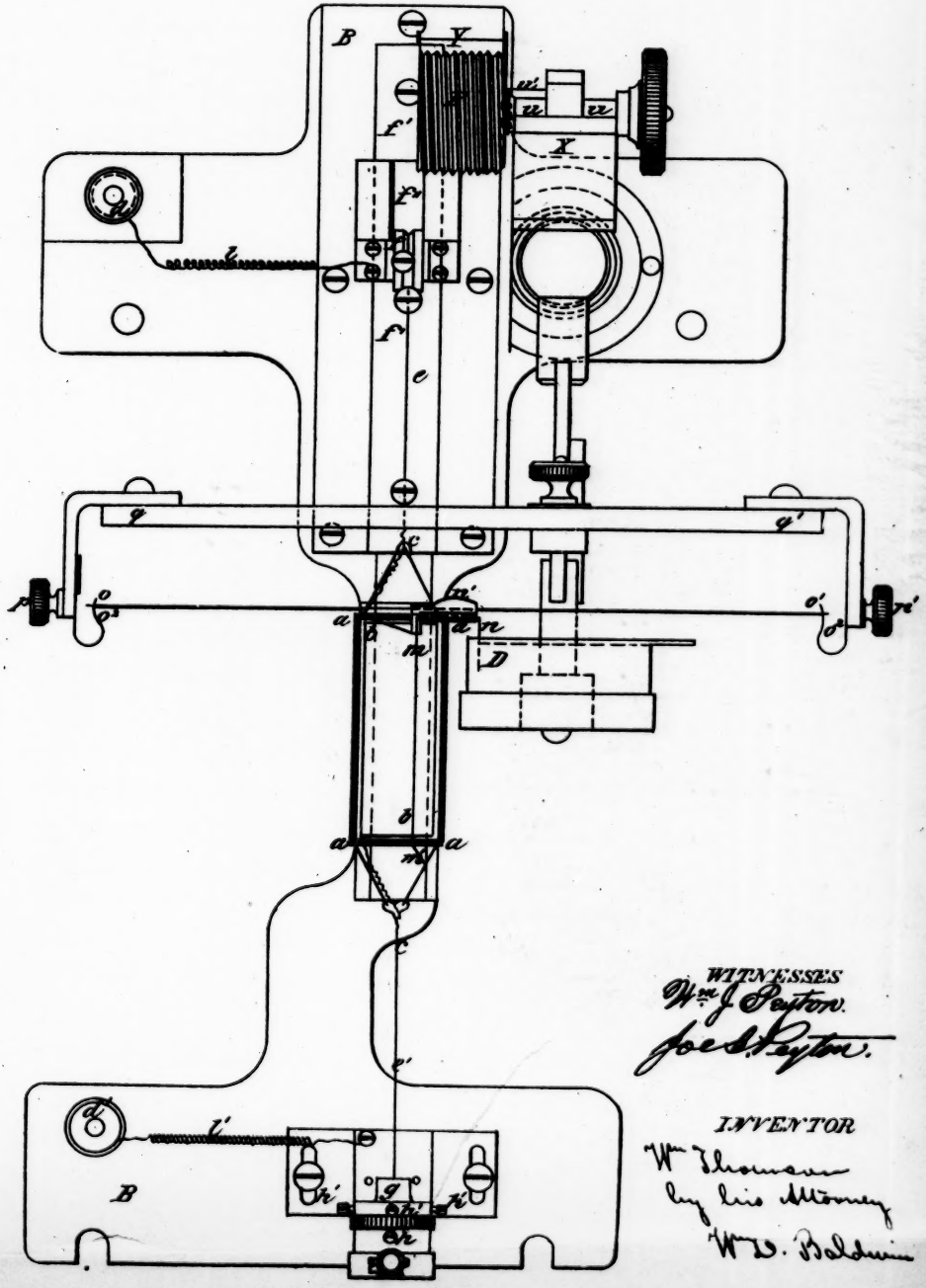
W. THOMSON.

Electric-Telegraph Apparatus.

2546

No. 156,897. Patented Nov. 17, 1874.

Fig. 7 (Sheet 7)



WITNESSES
Wm. J. Peyton.
Joe S. Peyton.

INVENTOR
Wm. Thomson
by his Attorney
Wm. D. Baldwin

2618

transmitting mechanism, the paper-moving mechanism, and the switch and shunt, so that the same paper may be employed to record both signals transmitted and signals received.

19. The combination and arrangement, substantially as before set forth, of the suspended signal coil, the siphon or marking tube, the inductor, the two constant springs for giving positive and negative signals, and the switch, so that, in a machine producing marks by the operation of a suspended coil, positive and negative signals may be given by two contact springs only.

WILLIAM THOMSON.

Witnesses:

JOHN DUNCAN,
45 West George street, Glasgow,
Clerk at Law.

DUNCAN MCINTYRE,
45 West George street, Glasgow,
Clerk at Law.

2619

[No. 60.] Defendants' Exhibit, Letters Patent to Alfred G. Holcomb, dated June 4, 1881, No. 32,478.

J. A. W., Special Examiner, June 7, 1884.

[Introduced in Record, p. 13.]

ALFRED G. HOLCOMB, OF NEW YORK, N. Y.

Improved Electric Magnet.

Specification forming part of Letters Patent No. 32,478, dated June 4, 1861.

To all whom it may concern:

Be it known that I, Alfred G. Holcomb, of the City, County and State of New York, have invented certain new and useful improvements in Electric Magnets, and I do hereby declare that the following is a full, clear and exact description of the same, reference being had to the accompanying drawings, making part of this specification, in which

Figure 1 is a perspective view of a relay magnet, embodying my improvements. Figure 2 is a perspective view of a permanent magnet hereinafter described.

Similar letters of reference indicate corresponding parts in both figures.

My invention consists, first, in a peculiar manner of applying induced magnetism from a permanent magnet in conjunction with electro-magnetism, as hereinafter explained. Second, in a peculiar construction and arrangement of the permanent magnet in connection with the electro-magnet. Third, in a device for supporting and adjusting the armature. Fourth, in an improved device for adjusting the armature spring.

To enable others skilled in the art to make and use my invention, I will proceed to describe its construction and operation.

A A′ represent helices of common construction provided with soft metal cores, *a a′*.

B is a permanent horse-shoe magnet placed horizontally beneath the helices and turned up vertically in the rear, its poles *b b′* being connected with the rear ends of the respective cores *a a′*.

C is the armature, supported upon points in cupbearings upon a slide, D, which by means of an insulated set screw, *d*, may be moved toward or from the cores *a a'*.

The armature spring consists of a straight steel wire, E, stretched between a loose nut, *f*, upon a screw-shaft, F, and a tightening shaft, G, a threaded shaft, F', being placed near the shaft G to hold the wire and adjust its position.

c is the armature lever.

i is the insulating point and *j* the platina point for closing the circuit.

The magnetism induced in the cores by the permanent magnet B operates in combination with the electro-magnetism, and by this means a magnetic force is developed greatly in excess of the sum of the forces of the induced and electro-magnetism when used separately. I am thus enabled, without increased expense or chemical action in the battery, to exert a greater force upon the armature than is possible without the combination of the permanent magnet. The length of the coil may be thus produced and the armature may be worked successfully at a greater distance from the cores. Reducing the length of the coils lessens the resistance to the passage of the electric current, and removing the armatures farther from the cores removes the necessity of frequent and delicate adjustment of the armature or spring. By placing the permanent magnet in a position parallel with the axes and near the periphery of the helices it is influenced by the electric current passing through the latter and by this means the power of the induced magnetism in the cores is increased.

In working the instrument the tension of the spring is adjusted so as to overcome the power of the induced magnetism from the permanent steel magnet, thus holding the armature *in equilibrio* while the battery is disconnected.

In the illustration here given my invention is represented as applied to the electrio-magnetic telegraph; but it is equally applicable to other uses of the electro-magnet.

I am aware that a permanent magnet has previously been combined with an electro-magnet, and do not, therefore desire to be understood as claiming the said combination, broadly, without reference to the particular manner and object of its use by me; but

What I do claim as new and of my invention herein, and desire to secure by letters patent, is,

1. Combining with the positive or attractive force of the electro-

2622

magnet that of a permanent steel magnet placed at or near the end of the core or cores of the electro-magnet opposite to that of the armature.

2. The use of a permanent steel magnet connected with the rear end of the core or cores of the electro-magnet and carried round in a position parallel, or nearly so, with the periphery of the helix or helices.

3. The combination, with the armature C, of the adjustable slide D and set screw *d*, in the manner and for the purposes set forth.

4. The adjusting screws F F′, or either of them when used in the described combination, with the stretched wire spring E, of the armature, for the purpose explained.

A. G. HOLCOMB.

Witnesses:

OCTAVIUS KNIGHT,
JAMES H. GRIDLEY.

(No. 61.) Defendants' Exhibit, "Improvement in Magnets."—From "The Scientific American," October 20, 1860, Vol. III., No. 17, New Series, page 264.

J. A W., Sp. Ex.

[Introduced in Record, p. 14.]

IMPROVEMENT IN ELECTRO-MAGNETS.

The practical working of the electric telegraph has caused a very wide diffusion of a knowledge of electricity and magnetism among our people, and the hope of making valuable inventions in this department of the arts has led to an intense study of the various phenomena of these forces. We have already described a number of inventions in telegraphing, and the field seems to be just fairly opening before our inventors. The invention which we here illustrate does not relate to the details of telegraphing, but is an improvement in the electro-magnet for whatever purpose used.

A permanent steel magnet, C, has connected with its two poles, A and B, the soft iron cores of two helices, D and E. In front of the poles of these cores is placed the armature, F, to which is attached the straight steel wire, *g*, operating as a spring by being drawn a little from a straight line between the two points to which the ends are fastened.

Supposing the magnet is to be used as a relay magnet in telegraphing, the spring is so strained that it will just balance the power induced in the cores by the permanent magnet, in which case the platinum point at the lever *h*, to which the armature is attached, will be neither fully in contact with the corresponding point on the standard I, nor yet so far removed from it as to entirely break the local circuit. Now, if the electricity be so passed through the helices D and E, so as to add its force to the influence of the permanent magnet, the magnetism of the cores will be so increased that they will draw the armature forward, thus completely and certainly breaking the local circuit. Then, if the current be reversed, so as to counteract the influence of the permanent magnet on the soft iron cores, the power of the spring will draw back the armature, effectually closing the local circuit. It will be

2624

seen that this arrangement permits the employment of a spring twice as powerful as if no permanent magnet were used, or it enables a spring of given power to operate with a current of half the force.

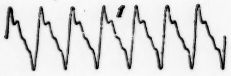
The inventor says this magnet has been thoroughly tested for telegraphing, and found practicable, and that it can be easily applied to every kind of telegraph instruments.

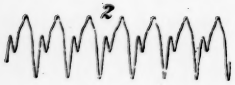
A patent for this invention was granted on the 15th day of May, 1860, and further information in relation to the matter may be obtained by addressing the inventor, Alfred G. Holcomb, of this city.

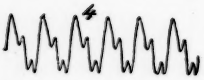
Mr. Holcomb informs us that, to measure the increase of attractive power produced in the soft iron cores of the helices by the combination of the steel magnet and the battery, he arranged a delicate lever, like a steelyard, to draw away the armature from the ends of the cores by means of a weight, and obtained the following very singular results, showing that the power of the cores under the combined action of the battery and permanent magnet was greater than the sum of its powers under the influence of the two separate. In the table below the first column shows the power of the cores when subjected to the battery alone, with currents of varying force; the second column its constant power under the influence of the steel magnet alone; the third column, the power when both were combined, and the fourth column the difference between the third and the sum of the first two. The close relation between the first and the fourth is very curious. The numbers are units of the weight used:

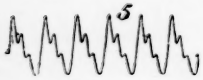
Battery power.	Power from steel magnet.	Power from both combined.	Excess of combined power over both separate.
5	20	30	05
7	20	34	07
10	20	39	09
17	20	52	15
20	20	58	18
24	20	62	18

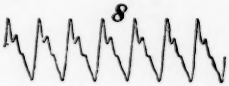
2625

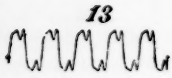


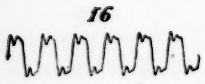












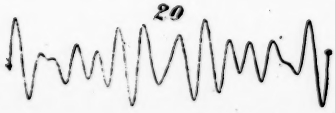


Plate 2

2626

[No. 62.] Defendants' Exhibit, Prof. Blake's Compound Harmonic Curves.

[Introduced in Case, p. 303.]

J. A. W., Sp. Examiner.

"SPECIMENS OF THE CURVES DRAWN BY THE MACHINE ARE GIVEN IN PLATE 2.

Nos. 1 to 8 (inclusive) are combinations of the first four terms of the Harmonic Series:

Ratios of Vibration	1	2	3	4
Amplitudes of Vibration	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$

No. 1. All four tones in the same phase when starting.
" 2. Tone 1 advanced $\frac{1}{4}$ vibration "
" 3. " 2 " " " "
" 4. " 3 " " " "
" 5. " 4 " " " "
" 5a. " 1 " $\frac{1}{8}$ " "
" 6. " 2 " " " "
" 7. " 3 " " " "
" 8. " 4 " " " "

Nos. 9 to 18 (inclusive) are combinations of the first three odd terms of the Harmonic Series:

Ratios of Vibrations	1	3	5
Amplitudes of Vibration	1	$\frac{1}{3}$	$\frac{1}{5}$

No. 9. All three tones in the same phase when starting.
" 10. Tone 1 advanced $\frac{1}{8}$ vibration "
" 11. " " " $\frac{1}{4}$ " "
" 12. " " " $\frac{3}{8}$ " "
" 13. " 3 " $\frac{1}{8}$ " "
" 14. " " " $\frac{1}{4}$ " "
" 15. " " " $\frac{3}{8}$ " "
" 16. " 5 " $\frac{1}{8}$ " "
" 17. " " " $\frac{1}{4}$ " "
" 18. " " " $\frac{3}{8}$ " "

Nos. 19 and 20 are combinations from the Diatonic Scale. No. 19 shows the Common Chord, *Major:*

Ratios of Vibration..... 1 : $\frac{5}{4}$: $\frac{3}{2}$

No. 20 shows the Common Chord, *Minor:*

Ratios of Vibration..... 1 : $\frac{6}{5}$: $\frac{3}{2}$

In both, the intensities of the component tones are equal, and their phases at starting identical."

2628

(No. 63.) Complainants' Exhibit, Holcomb Affidavit.

J. A. W., Sp. Ex'r.

[Introduced June 2, 1884.]

UNITED STATES CIRCUIT COURT,

DISTRICT OF NEW JERSEY.

AMERICAN BELL TELEPHONE COMPANY ET AL.

AGAINST

JOHN J. GHEGAN.

UNITED STATES OF AMERICA,
Southern District of New York, } ss.:
City and County of New York,

ALFRED G. HOLCOMB, being duly sworn, deposes and says:

I reside in the City of New York, and am about fifty-two years of age. I am an electrician, and am at present connected with The Standard Electric Light Company. I have made the subject of electricity a special study for the last thirty years, and have also given considerable attention to the subject of sound in its various applications.

I have made several inventions relating to electrical subjects, for which I have obtained letters patent. I am also familiar with the action of the various telephonic apparatus which have been invented and put into use during the past few years.

In the winter of 1859–60, I invented a polarized electro-magnet, consisting of a compound permanent U magnet, having its polar extremities bent laterally at right angles, each pole having a soft iron pole extension, surrounded by a helix of fine insulated wire. The said polar extensions and helices projected at right angles from the polar extremities, and were parallel with the body of the compound magnet. This magnet is an extremely sensitive one, and is capable of receiving articulate speech, as deposed by Mr. George M. Hop-

2629

kins in this suit. It was patented in the United States on the 15th day of May, 1860, and a description of it was published in the "Scientific American," a newspaper printed in the City of New York, on or about October 20th, 1860.

About the time I procured said patent I conceived the idea of converting the force of the human voice into electricity. This idea occurred to me while reading "Farraday's Researches" at the Astor Library, in New York City.

Early in the fall of 1860 I constructed a telephone consisting of one of my polarized magnets, which I have above described, a wooden diaphragm mounted on a box or mouth-piece, and a U-shaped soft iron armature attached to the said wooden diaphragm, and extending towards, and in proximity to, the ends of the polar extensions of the before-mentioned polarized magnet, but not touching them.

The diaphragm box and the polarized magnet were secured to and held in their relative positions by a base common to both. One of the instruments so constructed by me is shown in a drawing which I have marked for identification, "Deft.'s Ex. B." Soon after completing this instrument I made a duplicate of it, and connected the helices of both of the polarized magnets in a complete or closed electrical circuit, and while listening at one of the instruments I was able to hear and recognize articulate words spoken into the mouth-piece of the other instrument by other persons. I so used these instruments on several occasions. I showed the said instruments to several persons, and now have in my possession the essential parts of one of my first telephones. These instruments, at or about the time of their construction, and subsequently thereto, were used by me at my residence in Fifteenth street, in the City of New York, and were also operated at other places in said city. I intended to further improve my telephone, which then embodied all the essential features of the present magneto telephone, but was prevented from so doing owing to a lack of financial aid and the necessity of devoting my time to such pursuits as would bring in ready money. Although I was diligent in my efforts to obtain the aid and assistance of capitalists, I was unable to interest them in my invention. Had I procured the necessary financial assistance I should have filed at an early date applications for letters patent, which would have fully covered my telephonic inventions. However, I was not able to make application for a patent until January, 1878.

This application was subsequently put in interference with the

early so-called Telephone Patents of A. C. Bell, and with the applications of several other parties, which interference is still pending before the Patent Office. I filed my preliminary statement in due time, and made arrangements for the taking of my testimony, but was finally unable to do so on account of a lack of funds.

Had I obtained the necessary assistance to properly contest my right to a patent, it is my firm belief that I should have obtained a grant of letters patent, covering the subject matter involved in the various interferences, to which I was a party, and fully established my claim to prior inventorship of the speaking telephone. The statements aforesaid, as to my telephonic inventions, can be corroborated by other persons who were cognizant of the facts.

I have examined the Letters Patent No. 174,465, and 186,787, granted to A. G. Bell for improvements in telegraphy, and I believe I understand the construction and mode of operation of the so-called Bell Telephone therein described and set forth, and I am of the opinion that there is no essential feature in the said Bell instrument that was not contained in my telephone made in 1860.

I am also of the opinion that the method of transmitting speech, so used by Bell, is the same as the method employed by me for the same purpose in 1860.

ALFRED G. HOLCOMB.

Subscribed and sworn to before me, this 1st day of July, A. D. 1882.

[SEAL.] EDWARD KENT, JR.,
Notary Public,
Kings Co.

Certificate filed in N. Y. Co.

2631

(No. 64.) Complainants' Exhibit, Van der Weyde "Tribune" Article of January 8th, 1869.

J. A. W., Special Examiner.

[Introduced in Case, p. 25.]

"New York Daily Tribune," Volume XXVIII, Number 8659, January 8th, 1869.

Polytechnic Club.

At the regular meeting of the Polytechnic Branch of the American Institute, held last evening, at their room, No. 24 Cooper Institute, after the reading of a number of scientific notes by the President, Prof. Tilman, Dr. Van der Weyde explained the construction and operation of the telephone, a recent German invention for transmitting sounds by means of electricity. The operation of the apparatus depends upon the principle that a metallic bar becomes lengthened by being surrounded by a current of electricity, and returns to its original length when the current ceases to flow around it. The sounder in this instrument consists of a small iron rod enveloped in a coil of insulated wire. An electric current passed through the coil causes the inclosed rod to lengthen and its end to strike against a brass plate, producing a vibration of the plate.

In another room was placed the transmitting instrument, which consists of a small wooden box with a pole (hole? D. B. C.) in the top, closed by a piece of bladder or parchment; to this bladder is attached a metallic point connected with one of the wires leading to an electric battery, and immediately opposite to and almost in contact with another metallic point fixed to the bottom of the box, and connecting with another wire of the battery; the slightest vibration of the diaphragm brings the two points in contact and completes the galvanic circuit, when the electricity instantly passes along the wire and through the coil, causing the inclosed bar to expand and strike the brass plate. As the tone of any sound is determined by the rapidity of the vibrations which it causes in the air, it is claimed that by projecting into the above described box a musical note, the vibrations of the air will be communicated to the elastic diaphragm, causing an equal number of contacts of the metallic points, and consequently of electric passages through the wire coil. The in-

closed bar expands with each passage of the electric current, striking the plate and communicating to it the same number of vibrations as are received by the membrane of the sounding box. In the experiments tried at the meeting last evening a person sang into the box in one room, and the result was a succession of corresponding tones from the iron plates of the sounding instrument in another room. The sounds produced were very faint and low, requiring the ear to be held close to the sounding plate in order to distinguish them. The demonstration was considered as hardly satisfactory, although the experiments excited a good deal of interest, and several of the scientific men present seemed to think that the idea might be the germ of important results in the future.

The meeting adjourned to next Thursday evening at the same place.

2633

(No. 65.) Complainants' Exhibit, Van der Weyde Polytechnic Record.

J. A. W., Special Examiner.

[Introduced in Case, p. 35.]

THE TELEPHONE.

Dr. Van der Weyde exhibited a "telephone," invented by Mr. Kirpath, of Troy, N. Y., by which musical sounds may be transmitted. A cylindrical box, over one end of which a diaphragm of bladder was stretched, was provided with a speaking tube. In the centre of the diaphragm was placed a small piece of platinum. This platinum was in full connection with one pole of a galvanic battery, by means of a wire attached thereto. The other pole of the battery connected with a point which was placed above the piece of platinum, almost, but not fully, in contact with it. When a sound was made in the tube the vibrations of the diaphragm brought the piece of platinum in contact with the point as many times as there are undulations necessary to produce that sound. This instrument was connected with a straight-bar electro-magnet. When the connection with the battery was made the magnet lengthened, and when it was broken the bar returned to its original length. As this took place, for every vibration of the diaphragm there was a corresponding vibration in the sounding-board on which the magnet was placed, giving a tone which corresponded to the one originally sounded.

After the examination of this interesting apparatus the meeting adjourned for one week.

2654

(No. 66.) Complainants' Exhibit, Van der Weyde Affidavit.

J. A. W., Sp. Examiner.

[Introduced in Case, p. 39.]

STATE, CITY AND COUNTY OF NEW YORK, ss.:

PETER H. VAN DER WEYDE, of said city, being duly sworn, saith as follows:

My name is Peter H. Van der Weyde; age sixty-seven years; residence Brooklyn, N. Y. I was formerly Professor of Physics and Chemistry at Girard College, at the Cooper Institute, New York, and in the New York Medical College. I was also, in 1869, and subsequently, editor of the "Manufacturer and Builder," and am now editor of the "Practical American." I was at one time connected with the "Scientific American," in an editorial capacity.

My attention was directed in 1867 to the electrical transmission of sound, and particularly to that form of apparatus in which the voice of the speaker actuated the transmitter. I became familiar with the "Reis Telephone," constructed one and publicly exhibited it at the American Institute, with some improvements of my own, and on two occasions explained them to the American Association for the Advancement of Science at two annual meetings.

I think that I was, and down to the time of Mr. Bell's patent 174,465, March 7, 1876, continued to be familiar with all that was publicly known on the subject. I have reason to believe that the instruments I constructed were the most perfect known before Mr. Bell's patent, in which any sound was produced at a distant station by the voice of the speaker at the transmitting station. But neither the instruments then made, nor any others that were known before Mr. Bell's invention, were capable of transmitting articulate speech. My opinion on this subject is best shown by an article which I wrote and published in 1869 in the "Manufacturer and Builder" for May, 1869, Vol. I, page 129.

2635

From this article I make the following extract:

"It is clear from the foregoing explanations that no quality of tone can be transmitted, much less can articulate words be sent, notwithstanding the enthusiastic predictions of some persons who, when they first beheld this apparatus in operation, exclaimed that now we would talk directly through the wire. It is from its nature able to transmit only pitch and rhythm, consequently melody, and nothing more.

"No harmony, nor different degrees of strength, or other qualities of tone can be transmitted; the receiving instrument, in fact, sings the melodies transmitted, as it were, with its own voice, regardless of the quality of the tone which produces the original tune at the other end of the wire."

The opinion then expressed was not only my opinion but was the opinion of the scientific world. The discussions and conversations which ensued upon the reading of my two papers before the American Association, left me in no doubt as to the opinions of men most qualified to judge; for it was recognized that the method and mode of operation of the Reis apparatus was such that not only it did not transmit speech, but that speech could not be transmitted by the method according to which that apparatus operated.

I ought to explain that the inability of the Reis apparatus to transmit the feature of strength as well as pitch, did not merely disable it from indicating, whether the person at the transmitting end sang loudly or gently; it disabled it from transmitting *quality of tone*, upon which articulation depends, and made the sound produced at the receiving end regardless of the *quality* of the tone at the transmitting end. It operated by making and breaking the circuit, and any apparatus having this mode of operation was inherently incapable of transmitting articulate sounds, because it could not take note of the element of strength, and of the partial tones which constitute articulation, according to the well-known theory of Helmoltz. It takes note of and reproduces the *pitch*, which, as Helmoltz says, "*depends solely on the length of time in which each single vibration is executed, or*, which comes to the same thing, *on the vibrational number of the tone.*

"We are accustomed to take the second of time as the unit, and consequently mean by *vibrational number* the number of vibrations which the particles of a sounding body perform in one second of time." On the other hand, Helmoltz says, "that the *quality* of

tones should depend upon the manner in which the motion is performed within the period of each single vibration;" in other words, he says that "every different quality of tone requires a different form of vibration." He proceeds to show that *quality* of sound depends upon the existence and the loudness of the upper partial tones which are present as part of it, and adds, that "the existence and loudness of the upper partial tones which accompany the prime depend also on the vibrational form."

Near the close of his investigation, he says: "Hence we are able to lay down the important law that differences in musical quality of tone depend solely on the presence and strength of partial tones." The controlling effect of differences of strength of the upper partials or *quality*—and articulation is merely a *quality* of sound, though perhaps, of the most complicated character—is strikingly and correctly stated in *Mayer on Sound*, page 149:

"This fact proves that the quality of a sound does not depend alone on the number of the single harmonic sounds which compose it, but also on their relative intensities.

It can, indeed, be shown by calculation that, if the compound sound be formed of six single harmonic sounds, you can, by giving to each harmonic only two different degrees of intensity, form by their various combinations upwards of four hundred different qualities of sound; and with four different degrees of intensity allowed to each of the six harmonics, their combination can produce over eight thousand different qualities of sound. Thus you see, how varied may be the qualities of sounds even when they contain the same simple sounds."

After my attention had been called to apparatus exhibited by Mr. Elisha Gray (which was not at all a speaking telephone, but was a circuit-breaking musical telephone, having essentially the mode of operation of the Reis apparatus, and, therefore, like it incapable of transmitting speech), I wrote another article on telephones in the "Scientific American" of March 4, 1876, in which I referred to Mr. Gray, and also re-described the Reis apparatus. But I was well aware at that time, that no instrument was publicly known which was not inherently incapable of transmitting articulate speech. This article was published three days before the date of Mr. Bell's said patent.

I have read Mr. Bell's said Patent 174,465, of March 7, 1876, and understand it. The apparatus there shown I believe to be new, but the invention therein described consists chiefly in the introduction

2637

and use of an entirely new method and mode of operation. This I believe to be the opinion of the scientific world.

(Signed) P. H. VAN DER WEYDE.

Sworn to before me,
August 9, 1880.
(Signed) PHILIP JORDAN,
[NOTARIAL SEAL.] Notary Public, N. Y. Co.

UNITED STATES OF AMERICA,
Southern District of New York, } ss.:

I, TIMOTHY GRIFFITH, Clerk of the Circuit Court of the United States for the Southern District of New York, do hereby certify that the foregoing printed paper is a true and correct copy of an affidavit used upon a motion for a preliminary injunction in the suit of The American Bell Telephone Company *et al.* vs. The People's Telephone Company *et al*, now on file and remaining of record in my office.

In witness whereof, I have subscribed my name and have caused the seal of said Court to be hereunto affixed, this twentieth day of March, in the year of [SEAL.] our Lord, one thousand eight hundred and eighty-four, and of the Independence of the United States of America the one hundreth and eighth.

TIMOTHY GRIFFITH,
Clerk.

2638

(No. 67.) Defendants' Exhibit, Smithsonian Institute, No. 1.

J. A. W., Special Examiner.

[Introduced in Case, p. 44.]

SMITHSONIAN INSTITUTION,
WASHINGTON, D. C., August 8, 1874.

DEAR SIR—I write to request that you will send us a part of the acoustic apparatus ordered last year, to the amount of, say, 3,000 francs.

Among the instruments, I wish especially to have the "Grande Soufflerie No. 75." I leave the selection of the other articles to yourself. You have an account of what I purchased from you in 1870, during the war.

I have made a series of experiments on fog signals and find the siren trumpet to be, by far, the most powerful. It was with one of these instruments that Prof. Tyndall made his experiments, and which he found to be superior in penetrating power to an 18-pounder cannon.

You will please deliver the apparatus when completed to G. Bossange & Co., 16 Rue du 4 Septembre, and send us the bill and we will remit the money as early as 1st of January, when our interest becomes due.

Yours truly,
JOSEPH HENRY,
Secy. Smith. Institu.

MR. RUDOLPH KÖENIG,
30 Rue Hautefeuille,
Paris.

2639

(No. 68.) Defendants' Exhibit, Smithsonian Institute, No. 2.

J. A. W., Special Examiner.

[Introduced in Case, p. 44.]

PARIS, October 12, 1874.

PROF. HENRY, &c.:

SIR—I have the honor to enclose herewith an invoice of the instruments which, according to your order, I delivered to Mr. Bossange, October 9. You will find in the box of tuning forks in No. 30*c* (or 218*a*) a screw on which is a little disc of platinum and a small piece with a platinum wire. The first is intended to be substituted for the cup of mercury and the latter to be put in place of the circuit breaker on the tine of the tuning fork when it is desired to break the electric circuits by dry contact.

I have also a remark to make in regard to the 8 rectangular pipes in No. 99. After making them with extreme accuracy, I found that they, like all organ pipes, exactly follow the law according to which theoretical half-wave of its fundamental is equal to the length of the pipe plus twice its depth, and that the pretended law according to which "rectangular stopped pipes have the same sound whatever their breadth, if the product of the height by the depth is the same," is erroneous. In fact, the eight pipes of the series made so that the products of the ledgth by the depth should be the same, have the lengths 4′, 4′, 5″, 5′, 14″, 6′, 7′ 2″, 9′, 12′, 18′; the depths, 9′, 8′, 7′, 6′, 5′, 4′, 3′, 2′, or,

2 9 4 = 22, 2 8 4.5 = 20′5″, 2 6 6 18.
2 4 9 = 17, 2 2 18 = 22, 2 7 5.14 = 19.14,
2 5′ 7.2 = 17.2, 2 3 12 = 18.

and the sounds of the pipes correspond to these wave lengths and are not in unison. You see that the wave lengths for the four pipes which have the depths 6′ 5′ 4′ and 3′ are not very different; those pipes almost sound in unison, and it was evidently that fact which deceived Lavart, who did not know the general law.

Accept, &c.,

(Signed) R. KÖENIG.

2640

(No. 69.) Defendants' Exhibit, Smithsonian Institute, No. 3.

J. A. W., Special Examiner.

[Introduced in Case, p. 44.]

Delivered for the Smithsonian Institution at Washington by Mr. Rudolph Köenig, of Paris, 30 Rue Hautefeuille.

INVOICE.

CUT NO.		
1.	Eight pieces of wood	5 francs.
4.	Four tubes with pistons	26 "
5-8.	Four bows	32 "
9.	Whistling pipe	3 "
10.	Helicophone	1 "
12.	Locomotive whistle	25 "
13-20.	8 mouth-pieces	33 "
21.	Syren	16 "
23.	Sling	6 "
26.	Trevelyan's apparatus	14 "
27.	Rijke's tube	6 "
28.	Wertheim's apparatus	42 "
29.	Telephone	62 "
30 *c*.	Universal electric interrupter	1,100 "
38.	Table of numbers	2 "
49 *a*.	Ten steel cylinders	60 "
51.	Closed resonating box	50 "
55.	Comparing apparatus	130 "
59.	Glass globe containing a little bell	22 "
60.	Clock-work bell for same experiment	36 "
63.	Chaldui's apparatus	33 "
75.	Bellows and wind-chest	500 "
85.	Pipe with holes	16 "
87.	Tube with holes	16 "
88.	Cube with holes	16 "
89.	Gutta-percha tube	5 "
91.	Pipe with movable lip	16 "
93-94.	Four pipes to show effect of sides	22 "

2641

92.	Two pipes, one with mouth at the bottom	17 francs.
95.	Three pipes of copper, wood and paper	24 "
96.	Nine pipes for the law of dimensions	65 "
97.	Pipes with three pistons	45 "
99.	Eight rectangular pipes	68 "
100.	Two cubical tubes	20 "
101.	2 triangular prismatic pipes	22 "
102.	3 rectangular prismatic pipes	20 "
103.	2 glass pipes	10 "
104-107.	Four pipes for longitudinal vibrations	120 "
108.	Flute in four pieces	11 "
109.	Hydraulic piston apparatus	80 "
110.	Four different pipes, containing the same amount of air	44 "
111.	Three pipes, two of them conical	20 "
112.	Five mitred pipes	44 "
113.	Eight open pipes, forming the gamut	44 "
113 *a*.	Eight closed pipes	44 "
116.	Four pipes with circular mouths	22 "
	Box R. K. 54, 3 small boxes and packing	55 "
		3,070 "

Paris, 9 October, 1874.

2642

(No. 70.) Defendants' Exhibit, Smithsonian Institute, No. 4.

J. A. W., Special Examiner.

[Introduced in Case, p. 44.]

From Catalogue du Materiel Scientifique, of Rudolph Köenig, Aout 1872 (page 28).

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7. ACOUSTIQUE.

1. APPARSITA POUR LA PRODUCTION DU SOU ALANS LES PRINCIPAUX CAS.

x 1.	Huit morceux de bois donnant la gramme quand on les jetts par tem l'un oprès l'autre	4	francs.
x 2.	Quatre morceax de bois donnant l'accord parfait	2	"
x 3.	Marteau d'eau	5	"
x 4.	Quartre tubes avec piston, faisant entendre l'accord parfait, quand on ôte successivement leurs pistons	25	"
x 5.	Archet de coutre-basse	6	"
x 6.	" de basse	7	"
x 7.	" de violin	7	"
x 8.	" pour faire viber les plaques par milieu	10	"
x 9.	Tube Siffleur de Cagniard de Latour	5	"
x 10.	Helicophone	1	"
x 11.	Sampe philosophique	5	"
x 12.	Lifflet de locomotive	15	"
x 13.	Embouchure universelle	6	"
x 14.	" de tuyan à lèose mobile	6	"
x 15.	" de cor	3	"
x 16.	" de trumpette	3	"
x 17.	" d'ophicleide	3	"
x 18.	" de clarinette	3	"
x 20.	" de basson	3	"
x 21.	Moulinet Sirène de Cagniard de Latour, à tuyan cylindrique	15	"

2643

x 22. Le même à tuyan prismatique..... 15 francs.
x 23. Froude musicale de Cagniard de Latour..... 5 "
x 24. Sirène Voir No. 31.....
x 25. Roues dentées, Voir No. 32.....
x 26. Appareil de Trevelyan..... 12 "
x 27. Tube de verre et disque en toile de fil de fer pour l'experience de M. Rijke..... 5 "
x 28. Appareil de M. Wertheim (production de sous continus par l'ectricité..... 40 "
x 29. Telephone de M. Reis..... 60 "
x. Interrupteur èlectrique dans lequel le ressort est remplacé par un diapason, deux pinees garmes d'electro aimants, et trois diapasons ut—1, ut 1, et ut 2, arrangés de façons qu'ils puissent servir indistinctement pour l'interrupteur.....200 "

2644

(No. 71.) Defendants' Exhibit, Didaskalia, No. 130, May 11, 1862.

J. A. Welch, Sp. Examiner, May 13, 1884.

[Introduced in Case, p. 75.]

Telephony, that is, sound transmitting, is the name which that excellent physicist Mr. Reis, teacher at Fredericksdorf, gives his invention which is creating a sensation, and which is intended to use the *telegraph wires* for the *transmission* of actually *audible sounds*. Our readers will probably remember having heard long ago of this invention, with which Mr. Reis made his first experiments before the physical society in this city. Since then it has been in a continual process of improvement and will doubtless become of great importance.

Next Sunday, May 11, at 11 A. M., Mr. Reis will exhibit it at the regular session of the free German High School in the new hall. The necessary apparatus will be furnished with friendly willingness by Professor Bottger. We do not neglect to call the attendance of the readers of "Didaskalia" to this interesting session as the society admits also persons who are not members.

2645

(No. 72.) Defendants' Exhibit, Didaskalia, No. 133, May 14, 1862.

J. A. Welch, Special Examiner, May 13, 1884.

[Introduced in Case, p. 75.]

FRANKFORT, May 12th, 1862.

Yesterday's regular meeting of the free German High School was very largely attended, as the subject for the day, telephony by means of the galvanic current, discussed by the inventor Mr. Philip Reis, is of great interest and rightfully merits the most general attention. In a highly pleasing and very intelligible as well as clear and precise discourse Mr. Reis gave a historical sketch of the original development of his conception of the practical possibility of transmitting sounds by means of galvanism.

His first experiments failed, mainly by the consideration of the cardinal question put by himself: How is it possible for one single instrument to reproduce the combined action of all the organs brought into activity by human speech, until it occurred to him to solve the problem by a consideration of the following questions: How does our ear receive the resultant of the vibrations of all the organs of speech in activity at once? How do we observe the vibrations of several simultaneously sounding bodies? To solve this question the lecturer went into an explanation of the anatomy of the ear and the theory of the production of sounds in general, and firmly basing his theories upon these considerations he again took up his experiments in transmitting sounds by means of galvanism.

Mr. Reis then constructed on an enlarged scale a model of those organs of the ear which are concerned in the sense of hearing, and after numerous unsuccessful experiments he was at length enabled to transmit sounds which were received in this mechanical imitation of the ear. In the experiments made by him a few months ago at the Physical Society, the sounds were, to the surprise of all, exceedingly clear and distinct, while

the experiments following yesterday's lecture were less successful, owing mainly to the imperfect laying of the wires which in turn was caused by the unsuitable locality.

Although much yet remains to be done for a practical development of the telephone, by it a new and interesting field of labor has been opened to the physicist.

2647

(No. 73.) Defendants' Exhibit, The Book of Inventions, Trades and Industries, Leipsic. Publisher, Von Otto Spamen, 1872.

J. A. Welch, Special Examiner, May 13, 1884.

[Introduced in Case, p. 76.]

TELEPHONY.

It sounds more than wonderful when the possibility is asserted of carrying on a conversation with another person at a distance of hundreds of miles through the electric telegraph wire, so that he can hear with his bodily ear our voice with all its peculiarities, that he should hear the melody we are singing and that he should feel when we laugh, precisely as if he was standing alongside of us. But this possibility has, to a certain degree, already become to be a fact.

The master teacher Reis, in Franfurt on the Main, had the good idea to make of the electro-magnectic telegraph, "which has hitherto been an eye reaching over many lands," an ear which should reach full as far.

In this strange organ of hearing the electro-magnetic apparatus takes the part of those bones of the ear which carry the commotion from one membrane to another, and the only difference between the cavity of the ear and the union of two such stations is, that in one case we are made sensible of the striking of the sound waves against the ear drum by means of a lever, and in the other by means of the commotion of an iron rod.

Figure 417 shows us Reis's telephone, which has the following construction.

At the first station I there is a hollow box with a sound receiver A in front, into this sound receiver you sing the melody which you wish your distant hearer to hear. On top of the box there is an opening tightly covered with a membrane *m* of swinegut. On top of this membrane there lies a very thin plate of platina *p*, which is touched by the point of a pencil *n*, made of platina with a very sensitive spring. The point of this pencil is placed so that it will but just touch the plate *p* when the membrane is motionless, but leaves the same by each motion when the same swing to and fro.

2648

This alternate touch and separation stops and starts the electric current which comes from the Bunsen battery (three to four elements), and goes through the binding screws *a* into the plate *p*, and out of that into the pencil *n*, and to the second binding screw *b*. From *b* the wire leads to the second station and around the spiral C C, and goes from there through the binding screw *d* and through the wire *c* connected therewith back into the battery. In the centre of the spiral lies a small iron rod, fastened on both ends to the bridges *f f*, which rest on the sounding board *g g*. The parts *h*, *i*, *k*, *l* in both stations belong to a telegraphic arrangement, by means of which the attention of the distant audience may be called to the beginning of a message. The reproduction of a sound depends now mainly upon the commotion of the iron rod which is magnetised by the electric current moving around the spiral. As insignificant each single movement of the smallest parts may appear, they are strong enough to give the sensation of a sound through their regular and quick repeating and the assistance of the sounding board. The continuation of the currents going through depends on the vibration of the membrane *m*, in the first station, and consequently the sound reproduced in the second station must be in regard to its pitch in perfect accord with the sound sung into the sound receiver A.

As early as October, 1861, Reis had made successful trials with his apparatus. A melody sung with a medium loud voice was reproduced perfectly at a distance of 100 metres. Although the problem of "far-speaking" may so far only be considered solved in theory, and the apparatus has not yet that perfection which would make it possible for a speaker to interest large gatherings at numerous distant parts of the earth, it is nevertheless interesting enough to be described in this place.

2649

(No. 74.) Defendants' Exhibit, Aus der Natur. Vol. 21. Leipzig, 1862. Pages 470-4.

J. A. Welch, Special Examiner, May 14, 1884.

[Introduced in Case, p. 77.]

TELEPHONY.

The immense velocity of transmission possessed by electricity directed attention as long ago as the middle of the last century as to the possibility of using this unknown force for sending messages with rapidity to a great distance, but not until within twenty years has telegraphy, by means of the galvanic current, come into practical use, and has now so far advanced that the telegraphic apparatus, animated by the galvanic current, commits the messages to paper.

These surprising successes in the field of telegraphy have probably often pushed into the foreground the question of the possibility of the direct transmission of speech. Experiments in that direction, however, had not as yet shown any satisfactory results, because the vibrations of sound quickly lose their intensity, through the media of transmission, to such an extent that they become indistinguishable to our senses. Probably some have thought of a reproduction of sounds by means of the galvanic current, but the very persons who would have been the most capable on account of their knowledge and resources, hesitated to undertake the solution of the problem, and were most skeptical as to its practicability. To those less acquainted with physics, the problem, when they understand it, appears less difficult, because they do not foresee the difficulties.

So had Reis at Fredrichsfeld, at Frankfurt a. M., about nine years ago, as he himself says, with much enthusiasm for the novelty, and with limited knowledge of physics, the audacity to attempt a solution of this problem, but was soon obliged to abandon it, because the first experiment convinced him of its impossibility. Later on, after further study, Reis could see that his first experiment was very crude and in no wise convincing. But he did not then take up the question again in

earnest, because he considered himself unequal to the task of overcoming the obstacles to be encountered on the way. But the impressions of youth are strong and not easily obliterated, and consequently Reis could not banish the impression produced by his first experiment, and, in spite of the opposition of his judgment and half against his will, the project of his youth was taken up again at many a leisure hour, and the obstacles and the means of overcoming them balanced, but not as yet put to the test of experiment. How should one instrument reproduce the combined movements of all the organs brought into activity by human speech? This was always the cardinal question. At last Reis was struck with the idea of putting this question in a different form, as: How does our ear perceive the total vibrations of all the organs of speech in activity at the same time? Or, taken more generally: How do we perceive the vibrations of various bodies sounding at the same time? To answer this question let us see what must be done in the first instance to perceive each separate sound. Without an ear each separate sound is nothing but the quick repeating (at least seven to eight times a second) of rarefactions and condensations of a body. If this happens in the same medium in which we ourselves are contained, the membrane of our ear will be forced into the cavity of the ear with each condensation, and by the following rarefaction will move in the opposite direction. These vibrations cause the hammer to be lifted from and dropped upon the anvil in the same measure of time, or, according to others, an approach and recession of the minute bone atoms of the ear and a corresponding number of vibrations of the cochlea substance or fluid in which the ends of the nerve of hearing are spread.

The greater the condensation of the sound-conducting medium at a given moment, and the longer the vibrating width of the membrane and the hammer, the stronger, consequently, will be the stroke on the anvil, and the vibration transmitted through the fluid to the nerves. According to this it is the office of the organs of hearing to carry every condensation or rarefaction which occurs in their surrounding medium with accuracy to the nerve of hearing, and the office of the nerve of hearing is to bring the vibrations of matter in a given time, as well by number as by size, to our consciousness. Not until now do certain combinations receive definite names. Not until now do certain vibrations become melodies or discords. Whatever comes to the sensibility of the nerve of hearing is, therefore,

2651

merely the activity of a power brought to our consciousness, and this may be graphically illustrated by a curve, according to time and size, as in figure 1. The line *a b* is to indicate any given time, and the curve above the line (x) condensation, the curve under the line (—) rarefaction. So each ordinate erected at the end of an abscissa shows us the strength of condensation at a given moment at the starting point, in consequence of which the membrane vibrates. Anything other than can be illustrated by similar curves our ear is absolutely unable to perceive, and this is sufficient to bring every source and combination of sound clearly to our consciousness. When various sounds are created at the same time, the sound-conducting medium is under the influence of various simultaneous forces, and the following two laws are imperative. If all the forces act in the same direction, the size of the wave is proportional to the total of the forces ; but if the forces act in opposite directions, the size of the wave is proportional to the difference of the opposed forces.

If, for instance, we illustrate singly the condensation curves of three sounds, we can, by summing the ordinates of equal abscissae, designate new ordinates and establish a new curve, which we may call a combination curve ; and this will show us precisely what our ear perceives at the same time of the three combined sounds. That a musician would recognize again each separate sound is not to be wondered at more than the fact that one acquainted with the science of colors should readily discern in green the colors of blue and yellow. The combination curves show these differences in a very limited degree, as in them reappear successively all the proportions of the components. In accords of more than three sounds it is certainly not so easy to recognize the proportions in the drawing, but it is equally difficult for a good musician to distinguish in such accords each separate sound.

From the above we can see that as soon as it shall be possible to create vibrations anywhere and in any manner whose curves are equal to those of a certain sound or combination of sounds, we shall receive the same impression as the sound or combination of sounds would have produced.

Placing himself upon these principles, Mr. Reis succeeded in constructing a very simple apparatus, as shown in figure 2, by the aid of which he is enabled to reproduce the sounds of various instruments, and, to a certain degree, also the human voice. On the wooden cube (*r, s, t, u, v, w, x*) is the cavity (*a*), closed on one side

by the membrane (*b*) of hog's intestine, on the centre of which is fastened a platina strip, which serves as conductor to the galvanic current. This is connected with the binding screw (*P*). From the binding screw (*n*) another small metallic strip is placed over the centre of the membrane, and is connected with a platinum wire, which is placed at a right angle with the longitudinal axis and the broad side of the cube. From the binding screw (p) a conducting wire goes through the battery to a distant station, and ends there in a spiral of silk covered copper wire, which again leads back to the conductor, which ends in the binding screw (*n*). The spiral at the distant station is fully six inches in length, and carries six layers of thin wire, and has in its centre, as a nucleus, a knitting kneedle, which protrudes on each end fully two inches. The spiral rests with the protruding ends of the wire on two bridges of a sounding board. Of course, the whole of this part can be replaced by any apparatus by which you can produce the well-known galvanic tones. If, now, sounds or combination of sounds are produced in the vicinity of this block, so that strong waves will enter the opening (*a*), they will cause a vibration of the membrane (*b*). With the first condensation the hammer-shaped wire (*d*) will be pushed back ; with the following rarefaction the wire cannot follow the retreating membrane, and the current which flows through the strip remains interrupted until the membrane is driven back by a new condensation, and presses the strip again from (*p*) to (*d*). Every wave of sound thus produces an opening and closing of the current. Every closing of the circuit causes the atoms of the needle, at the distant station, to repel each other and to seek again their natural position at every interruption of the current. As this occurs they make, in consequence of the alternate action of elasticity and inertia, a number of vibrations, and give the longitudinal sound of the wire. Such is the action when the opening and closing of the current is comparatively slow. If they occur faster than the oscillations of the iron rod, which are dependent upon elasticity, are produced, if the fact that the atoms cannot describe their full course, their causes grow shorter as the interruptions grow faster, but still just as fast as these. The iron rod no longer gives its longitudinal sound, but a sound whose pitch agrees with the number of interruptions in a given time. All this means that the rod produces the sound that is transmitted to it through the interrupting apparatus. The strength of the sound, also, is in proportion to the original source, for the stronger the original sound, the stronger the vibration of the membrane, and the

2653

greater the movement of the minute hammer the longer time the circuit remains closed; and, consequently, the larger, to a certain degree, the movement of the atoms in the reproducing rod which we perceive as a longer vibration, just as we should have perceived the original wave.

As to the length of the conducting wire, it can be stretched as far as in telegraphy by the galvanic current. Reis has given this apparatus the name of telephone.

In regard to what it is able to accomplish, it may be mentioned that Reis has been able, before a largely attended meeting of the Physical Society, at Frankfurt-A.-M., to produce audible melodies which were sung, not very loudly, into an apparatus placed in the closed room of a house three hundred feet distant,

Other experiments have proved that the rod is able to reproduce triple sounds of a piano on which the telephone stands, Fig. 3, and finally that the same will reproduce the sounds of other instruments—such as the concertina, clarionette, horn, organ pipes, &c., provided the sounds belong to a certain range, say F to f.

It is needless to mention that at all these experiments there was sufficient investigation to prevent a direct conduction of sound. This investigation can easily be made by a good interrupter—placed close to the coil, which of course stops the operation of the instrument for the time being.

Up to this time it has been impossible to reproduce the sound of human speech in such a degree as to be perfectly audible to any one. The consonants were in most cases reproduced almost perfectly, but not so the vowels; the cause of this may be found in the following, as has been ascertained by the experiments of Willis, Helmholz and others: Vocal sounds can be artificially produced by increasing the vibrations of a body at intervals through another body, as for instance: An elastic spring is set in vibration by the stroke of a cog of a wheel; the first vibration is the largest, and every following one is smaller than its predecessor, Fig. 3.

If, after a few vibrations of this kind, another stroke follows, before the spring comes to a rest, the next vibration will again be the largest, and so on. The height and depth of a sound depends upon the number of vibrations made in a given time, and the character of the sound upon the number of such cog strokes in a given time. Two vowels at the same pitch may be illustrated and dis-

tinguished in figures 4 and 5, whereas the same sound without the attributes of a vowel may be illustrated by Fig. 6.

Our organs of speech probably produce the vowels in the same way through a combined action of the upper and the lower glottis, or the latter and the cavity of the mouth. The apparatus gives us the number of vibrations, but their force is much reduced from the original and most likely to a certain degree, proportionally among them all. This difference between the generally smaller vibrations is certainly much harder to recognize than the original wave, and, therefore, the vowels are more indefinite. There certainly remains much to be done towards a practical development of telephony, but, as the beginning has now been made, we shall not have long to wait for further advance. A broad field of labor has thus been opened for the physicist.

2655

(No. 75.) Defendants' Exhibit, British Letters Patent to John Henry Johnson.

J. A. W., Sp. Ex'r.

A. D. 1875, 16th March, No. 974.

[Introduced in Case, p. 410.]

TRANSMITTING MUSICAL VIBRATIONS.

LETTERS PATENT to John Henry Johnson, of 47, Lincoln's Inn Fields, in the County of Middlesex, Gentleman, for an invention of "Improvements in apparatus in transmitting musical vibrations or signals by means of electricity." A communication from abroad by Elisha Gray, of Chicago, County of Cook, State of Illinois, United States of America.

Complete specification filed by the said John Henry Johnson at the office of the Commissioners of Patents, on the 16th March, 1875.

John Henry Johnson, of 47, Lincoln's Inn Fields, in the County of Middlesex, gentleman. "Improvements in apparatus for transmitting musical vibrations or signals by means of electricity." A communication from abroad by Elisha Gray, of Chicago, County of Cook, State of Illinois, United States of America.

This invention relates to apparatus for transmitting musical vibrations by means of electricity from a distance, which apparatus is known as the telephone, and the invention consists in the method of, and apparatus for, transmitting and receiving simultaneously or otherwise, on a single circuit, two or more musical tones of different pitch.

It also consists in the combination of apparatus operating in the above-named manner with a series of Morse sounders or printing telegraph apparatus, each operated in its own local circuit, whereby it is rendered possible to transmit two or more messages simultaneously on a single main circuit.

And in order that the said invention may be fully understood I shall now proceed more particularly to describe the same, and for that purpose shall refer to the several figures on the annexed sheet of drawings, the same letters of reference indicating corresponding parts in all the corresponding figures.

Figure 1 of the accompanying drawings is a view in elevation of the instrument used for transmitting; figure 2 is a plan view of the same, showing the connections with the local and main circuits; figure 3 is a view in elevation of the instrument used for receiving, and figure 4 is a plan view of the same, also showing the connection with the main and local circuits; and figure 5 is a diagram showing the transmitting and the receiving instruments connected in a single main circuit, and the arrangement of the keys, sounders and local circuits at the transmitting and receiving stations, whereby two messages may be transmitted simultaneously.

In the specification of letters patent dated July twenty-ninth, one thousand eight hundred and seventy-four, No. 2646, granted to me on behalf of the said Elisha Gray, there is described a method of transmitting musical tones of any desired pitch by sending in series of electrical impulses corresponding in number per second to the number of audible vibrations per second in the musical tone which it is desired to produce through an electro-magnet, whereby the same is made to vibrate in correspondence with the impulses, and consequently gives forth the tone desired.

This method of transmitting musical vibrations is employed in carrying the present invention into effect.

This invention is also based upon the law that every vibrating string or bar of definite thickness, length and tension has a certain definite rate of vibration per second at which it will always vibrate with the production of a second definite musical note when in motion, which note is known as the fundamental of the bar or string.

I will now describe the construction and operation of the transmitting and receiving apparatus employed according to this invention, from which description the manner in which this law of vibrating strings is applied and utilized will be made evident.

These receiving and transmitting instruments are similar in

2659

their construction, but differ in the arrangement of their electrical connections.

A is the supporting base; B, B¹, are two columns of metal supported in this base; and C is a brass bar connecting these two columns. F is a frame of metal suspended under the bar C, and attached thereto, and I is an electro-magnet supported in the frame F whose poles extend through the bar *c*. The electro-magnet on the receiving instrument is wound with finer wire than on the magnet in the transmitting apparatus. D is a thin bar of steel which is stretched above the bar C, between suitable supports on the same, and has attached thereto a screw and head L, by means of which its tension may be regulated at will. This steel bar is over the projecting poles of the electro-magnet, but does not come in contact with the same. M, M¹, N, N¹, are binding screws, by means of which connection is made with the local and main circuits. The connections are different in the transmitting and receiving instrument, and I will first describe the connections of the former, which are shown clearly in the plan view in figure 2. Figure 1 shows an upright projection H, from the bar C, having a contact point *i*, therein which is opposed to a contact-piece on the bar D. O shows a contact point under and almost in contact with the bar D, which contact point is attached to a bar K, shown in figure 2.

The connections are as follows, and are shown in figure 2: From the local battery the current passes to binding screw N, then by wire *e*, to the projection H, then by contact point *i*, to bar D, then by the column B to the wire *d*, then through the magnet I and wire *a* to the binding screw N¹. The main current enters at the screw M, then passes by the wires *e* and *d* to arm K, and contact point O, to the bar D, then by column B¹ and wire *f* to the screw M¹.

When the local circuit is closed by means of a key in the usual manner the magnet will be excited and the bar D will be attracted; this will break the circuit at the point *i*, the spring bar D will then be released and the circuit will be again closed through the magnet. This automatic breaking and closing will continue as long as the circuit is closed at the key, and the result will be that the bar will be thrown into vibration a certain number of times per second, and will produce a tone of a pitch determined by the thickness, length and tension of the bar, and

containing exactly the same number of audible vibrations per second as these closures of the circuit at the point *i*.

The main circuit is closed at the point O every time the bar D is attracted, and a series of electric impulses are consequently transmitted to the main circuit corresponding in number to the audible vibrations in the fundamental tone of the vibrating bar.

At the receiving instrument shown in Figures 3 and 4, the main circuit enters at the point N, passes by wire *a* to the electro-magnet I, then by the wire *b* to the point N′, and thence to the ground. If there is a local circuit, it passes from screw M by wire *e* to bar H, and the contact point to bar D, and by wire *f* to screw M′. When the succession of electric currrents pass through the magnet I of the receiving instrument, it will be thrown into vibration on principle before explained, and will give forth a musical tone of the same pitch as that given by the vibrating bar at the transmitting instrument.

If the tone given by the magnet is the same as the fundamental of the bar D strectched above it, this bar D will be thrown into sympathetic vibration, and will also give the same tone, and during its vibration it will come against the point H and close the local circuit. If an electro-magnet is placed in this circuit, its armature will be attracted, and as the interruptions in the local circuit are so short as not to permit the demagnetization of the magnet and the consequent release of the armature the latter will remain down.

Figure 5 is a diagram representing two transmitting and two receiving instruments at opposite stations, connected by a single main circuit.

The vibrating steel bars *d* and *e* of the transmitting instruments are tuned to a different fundamental, and the steel bars e^1 d^1 of the receiving instruments correspond to each of those respectively. The bar *e* gives the note D C of the scale, and the bar *d* the note D. Each of these transmitting instruments has its independent local battery, which by the electro-magnet of each instrument is operated, and each instrument is connected as shown in branches with the single main circuit at the points L M and L^1 M^1.

At the receiving station the main circuit passes through the electro-magnets of both instruments; and each instrument is

connected at the points H N and H^1 N^1, with a local circuit passing through a sounder.

The method in which the apparatus operates is as follows:

If the local circuits be closed by depressing the key K K^1, the bars *e* and *d* will be vibrated, as before explained, and a series of impulses of electricity from the main battery will be transmitted per second to the line, the instrument C transmitting the same number of impulses as these audible vibrations to the note C, and the instrument D transmitting the same number of impulses as there are audible vibrations in the note D.

These electric impulses will all pass through the magnets I, I^1, of both the instruments C^1, D^1, at the receiving station, and will cause them to vibrate; but inasmuch as the bar e^1 above the electro-magnet I can vibrate at a certain rate only, it will give forth only its fundamental note C, and the bar d^1, above the electro-magnet I^1, will give forth only its fundamental note D, which corresponds with the tone produced at the transmitting station.

In this manner the two notes are produced simultaneously at the receiving station.

There may be as many transmitting instruments and independent local circuits as there are tones and semi-tones in two or more octaves, and each vibrating bar may be tuned to different notes on the scale. The instruments may be placed side by side, and then respective local keys are arranged like the keys of a piano, so that a tune consisting of notes and chords can be easily played; or the transmitting instruments may be separated at any distance from each other. At the receiving station there will be a corresponding number of instruments, and they may be side by side or also separated from each other by any distance. The transmitting instruments may be connected with an induction coil, by which means induced currents instead of ordinary currents may be sent to the wire.

Inasmuch as the vibration of each instrument affects the bar of the receiving instrument only, which is tuned to the same fundamental as the transmitting instrument corresponding to it, and as the main circuit pass through all the magnets and is therefore never broken unless all the instruments and the transmitting station are out of action, it is known that the interruption of one tone by opening the key corresponding

thereto will cause the cessation at the receiver of that tone alone, and that the other instruments will be unaffected, so that in this manner two or more signals may be transmitted simultaneously.

The signals may be given by short and long interruptions in a continuous tone, or by means of a Morse sounder, which is placed in a local circuit connected with each receiving instrument, as shown at S, S^1, in the diagram.

As long as the bar vibrates the local circuit through the magnet will close, but when these vibrations cease in obedience to the movement of the key at the transmitting station the local circuit will open and the armature lever will make a back stroke.

Printing instruments may be placed at these local circuits instead of Morse sounders, which will be operated on the interruption of the local circuit, and may be arranged in any manner which will occur to any person familiar with the method of telegraphing and the construction of telegraph instruments.

Instead of receiving the vibrations upon electro-magnets, as shown, they may be received upon a plate of metal by the method described in the specification before mentioned, and by the use of resonators or organ pipes, each tuned to a certain fundamental, any desired simple tone may be selected from the clang or compound tone which is produced by the vibrating plate.

Instead of automatic circuit breakers operated electrically, mechanical circuit breakers may be used, or the circuit may be broken by means of platina points in the reeds of organ pipes. This invention admits of being carried into effect in many different ways, which will be obvious to those skilled in the art to which it pertains.

Having now described and particularly ascertained the nature of the said invention, and the manner in which the same is, or may be used or carried into effect, I would observe in conclusion that what I consider to be novel and original, and therefore claim as the invention secured to me by the hereinbefore in part recited letters patent is :

FIRST. The method of transmitting two or more musical tones of different pitch simultaneously or otherwise through a single line wire by menns of two or more circuit interrupters,

2661

each acting independently but connected in the same main circuit to the line, and each transmitting to the line a succession of impulses of electricity of equal length, the number of impulses transmitted per second by each circuit interrupter being different, but equal for each circuit interrupter to the number of audible vibrations per second in a musical tone of a certain pitch, in combination with a vibrating or resonant instrument at the receiving station, which instrument is connected to the line, is a conductor of electricity, and is thrown into vibration by the impulses of electricity transmitted through it so as to give forth a musical tone, as and for the purpose hereinbefore described.

SECOND. In combination with two or more circuit interrupters, each acting independently but connected in the same main circuit to the line, and each transmitting to the line a succession of impulses of electricity of equal length, the number of impulses transmitted per second by each circuit interrupter being different but equal for each to the number of audible vibrations per second in a musical tone of a certain pitch, a vibrating and resonant receiving instrument which is a conductor of electricity, and which is thrown into vibrations by the impulses of electricity transmitted through it so as to give forth a musical tone, and two or more resonators, or analyzers, or organ pipes, each of which will vibrate to a certain fundamental tone only, substantially as and for the purpose hereinbefore described.

THIRD. In combination with two or more circuit interrupters, each acting independently but connected in the same main circuit to the line, and each transmitting to the line a succession of impulses of electricity of equal length, the number of impulses transmitted by each circuit interrupter per second being different, but equal for each to number of audible vibrabrations per second in a musical tone of a certain pitch, two or more receiving instruments which are in the same main circuit and are each provided with a vibrating bar or its equivalent which is pitched to a certain fundamental, and gives forth a musical tone when the number of electrical impulses transmitted through the receiver per second are equal to the number of audible vibrations in the tone to which the bar or its equivalent is pitched.

FOURTH. In combination with two or more circuit interrupt-

2662

2661

each acting independently but connected in the same main circuit to the line, and each transmitting to the line a succession of impulses of electricity of equal length, the number of impulses transmitted per second by each circuit interrupter being different, but equal for each circuit interrupter to the number of audible vibrations per second in a musical tone of a certain pitch, in combination with a vibrating or resonant instrument at the receiving station, which instrument is connected to the line, is a conductor of electricity, and is thrown into vibration by the impulses of electricity transmitted through it so as to give forth a musical tone, as and for the purpose hereinbefore described.

SECOND. In combination with two or more circuit interrupters, each acting independently but connected in the same main circuit to the line, and each transmitting to the line a succession of impulses of electricity of equal length, the number of impulses transmitted per second by each circuit interrupter being different but equal for each to the number of audible vibrations per second in a musical tone of a certain pitch, a vibrating and resonant receiving instrument which is a conductor of electricity, and which is thrown into vibrations by the impulses of electricity transmitted through it so as to give forth a musical tone, and two or more resonators, or analyzers, or organ pipes, each of which will vibrate to a certain fundamental tone only, substantially as and for the purpose hereinbefore described.

THIRD. In combination with two or more circuit interrupters, each acting independently but connected in the same main circuit to the line, and each transmitting to the line a succession of impulses of electricity of equal length, the number of impulses transmitted by each circuit interrupter per second being different, but equal for each to number of audible vibrabrations per second in a musical tone of a certain pitch, two or more receiving instruments which are in the same main circuit and are each provided with a vibrating bar or its equivalent which is pitched to a certain fundamental, and gives forth a musical tone when the number of electrical impulses transmitted through the receiver per second are equal to the number of audible vibrations in the tone to which the bar or its equivalent is pitched.

FOURTH. In combination with two or more circuit interrupt-

ers, each acting independently but connected on the same main circuit to the line, and each transmitting to the line a succession of impulses of electricity of equal length, the number of impulses transmitted per second by each circuit interrupter being different, but equal for each circuit interrupter to the number of audible vibrations per second in a musical tone of a certain pitch, two or more receiving instruments connected in the same main circuit, and each provided with a vibrating bar or its equivalent, which bar is tuned to a certain pitch and gives forth a musical note when the impulses of electricity transmitted through the receiving instrument correspond in number to the audible vibrations in the note produced by the said bar, and two or more local circuits through sounders or printers, each of which circuits is connected to a corresponding vibrating bar, and is closed when said bar is thrown into vibration, substantially as and for the purposes hereinbefore described.

FIFTH. A transmitting instrument, consisting of the combination of the magnet I, frame B, B^1, C, F, vibrating bar D, contact points 0 and *i*, and circuits *a*, *b*, *c*, *d*, *e*, *f*, substantially as hereinbefore described and illustrated by drawings.

SIXTH. A receiving instrument, consisting of the combination of the electro-magnet I, frame B, B^1, C, F, vibrating bar D, contact point H, and circuits *a*, *b*, *e*, *f*, substantially as hereinbefore described and illustrated by the drawings.

In witness whereof, I, the said John Henry Johnson, have to this, my complete specification, set my hand and seal, this ninth day of March, one thousand eight hundred and seventy-five.

J. HENRY JOHNSON [L. S.]

2664

(No. 76.) Defendants' Exhibit, Disclaimer and Memorandum of Alteration, of William Morgan-Brown, &c.

J. A. W., Sp. Ex'r.

A. D. 1876. No. 4765.

[Introduced in Case, p. 410.]

ELECTRIC TELEPHONY AND TELPHONIC APPARATUS.

MORGAN-BROWN'S DISCLAIMER AND MEMORANDUM OF ALTERATION.

Filed 13th February, 1878.

In the matter of letters patent granted to William Morgan-Brown of the firm of Brandon & Morgan-Brown, engineers and patent agents, of 38 Southhampton Buildings, London, and 1 Rue Laffitte, Paris, for the invention of "Improvements in Electric Telephony (transmitting or causing sounds for telegraphing messages) and Telephonic Apparatus." A communication from abroad by Alexander Graham Bell, of the University of Boston, Massachusetts, United States of America, professor of vocal physiology, bearing date 9th December, 1876, No. 4765.

Disclaimer and memorandum of alteration as proposed to be entered by the said William Morgan-Brown, of certain parts in the specification of the said letters patent, pursuant to the statute in that case made and provided.

Whereas, her most excellent Majesty Queen Victoria, by her letters patent, under the great seal of the United Kingdom of Great Britain and Ireland, bearing date the 9th day of December, 1876, No. 4765[76], did for herself, her heirs and successors, give and grant unto the said William Morgan-Brown, his executors, administrators and assigns, the sole privilege of making, using, exercising and vending within the United Kingdom of Great Britain and Ireland, the Channel Islands, and the Isle of Man, the said invention for the term of 14 years from the date of the said letters patent. And whereas, since

2665

the filing of the specification in pursuance of the said letters patent I, the said William Morgan-Brown, have ascertained that some of the claims made therein are too wide, and comprise, as forming parts of the said invention, parts that were not new in the United Kingdom at the date of the said letters patent, by reason of descriptions thereof having been published in England before the 9th December, 1876, and in particular certain descriptions of telephonic apparatus that had been invented and used by the said Alexander Graham Bell, in America, prior to the said date. And whereas, it has been ascertained that parts of the said invention, as described in the said specification, are not of sufficient practical utility. And whereas, I am desirous for the above reasons of amending my said specification by disclaimer and memorandum of alteration, as hereinafter set forth, and of confining the claims in the said specification to arrangements of telephonic apparatus, wherein are employed plate armatures or armatures other than those carried by a membrane, and arrangements wherein are employed permanent magnets or magnets excited by batteries which are not in the main circuit or line wire. And whereas, I, the said William Morgan-Brown, for the reasons aforesaid, am desirous, by and with the leave of her Majesty's Attorney-General, to disclaim the portions of the said specifications hereinafter mentioned, and to alter and amend the said specification in manner following—that is, by a disclaimer and memorandum of alteration, which cannot and does not extend the exclusive right granted by the said letters patent.

For the reasons aforesaid I insert after the word "apparatus" on page 11, line 12, of the Queen's printers' copy of the said specification (second edition) the words following, "as hereinafter described and claimed in the claiming clauses hereunto annexed;" and I strike out the whole of the paragraph on the same page 11, beginning with the words "in all," in line 12, and ending with the word "direction," in line 21; and on the same page 11 I strike out all the words from the word "whereby," in line 24, down to and including the words "confusion and," in line 26; and on the same page 11 I strike out the whole of the paragraph beginning with the words "the invention," in line 28, and ending with word "directions," in line 31; and I insert after the word "transmission," in line 32, of the same page 11, the words "in the manner hereinafter described

2662

2665

the filing of the specification in pursuance of the said letters patent I, the said William Morgan-Brown, have ascertained that some of the claims made therein are too wide, and comprise, as forming parts of the said invention, parts that were not new in the United Kingdom at the date of the said letters patent, by reason of descriptions thereof having been published in England before the 9th December, 1876, and in particular certain descriptions of telephonic apparatus that had been invented and used by the said Alexander Graham Bell, in America, prior to the said date. And whereas, it has been ascertained that parts of the said invention, as described in the said specification, are not of sufficient practical utility. And whereas, I am desirous for the above reasons of amending my said specification by disclaimer and memorandum of alteration, as hereinafter set forth, and of confining the claims in the said specification to arrangements of telephonic apparatus, wherein are employed plate armatures or armatures other than those carried by a membrane, and arrangements wherein are employed permanent magnets or magnets excited by batteries which are not in the main circuit or line wire. And whereas, I, the said William Morgan-Brown, for the reasons aforesaid, am desirous, by and with the leave of her Majesty's Attorney-General, to disclaim the portions of the said specifications hereinafter mentioned, and to alter and amend the said specification in manner following—that is, by a disclaimer and memorandum of alteration, which cannot and does not extend the exclusive right granted by the said letters patent.

For the reasons aforesaid I insert after the word "apparatus" on page 11, line 12, of the Queen's printers' copy of the said specification (second edition) the words following, "as hereinafter described and claimed in the claiming clauses hereunto annexed;" and I strike out the whole of the paragraph on the same page 11, beginning with the words "in all," in line 12, and ending with the word "direction," in line 21; and on the same page 11 I strike out all the words from the word "whereby," in line 24, down to and including the words "confusion and," in line 26; and on the same page 11 I strike out the whole of the paragraph beginning with the words "the invention," in line 28, and ending with word "directions," in line 31; and I insert after the word "transmission," in line 32, of the same page 11, the words "in the manner hereinafter described

2666

and claimed;" and on the same page 11 I strike out all the words from the words "and two" in lines 34 and 35 to the word "directions," in line 36, inclusive; and I insert after the word "transmission in the," line 37, of the same page 11 the words "in the manner hereinafter described and claimed;" and after the word "battery," in line 38, of the same page 11, I insert the words "being used in the main circuit or used," otherwise than in the manner hereinafter described and claimed;" and on the same page 11 I strike out all the words from the words "and two," in line 40, to the word "line," in line 47, inclusive; and after the words "first plan," in line 48, of the same page 11, I insert the words "to which no claim is made otherwise than in the claiming clauses hereunto annexed;" and in line 19, of page 13, I strike out the words as devised "by my communicator," and in lieu thereof I insert the words "following, to which no claim is made otherwise than in the claiming clauses hereunto annexed;" and after the words "third plan," in line 33, of the same page 13 I insert the words "to which no claim is made otherwise than in the claiming clauses hereunto annexed;" and after the words "fourth plan," in line 19, of page 17, I insert the following words: "which is not claimed further than is indicated by "the claims made in the claiming clauses hereunto annexed "and it is to be noted that no claim is made to the use of "telephonic apparatus wherein a membrane like gold beaters "skin is used in combination with an electro-magnet excited "by a battery which is arranged in the main circuit or line "wire, inasmuch that such a membrane was mentioned in "descriptions published in England prior to December 9th, "1876, and as such a membrane is of small utility owing to "its uncertainty of action caused by changes due to wear, or "moisture, or atmospheric influences;" and in line 25 of the said page 17 I strike out the word "fourth;" and in line 55 of the same page 17 I strike out the words "may be used," and insert in place thereof the words "such as is shown at A^3 in Figure 31 of the drawings hereunto annexed may with greatly increased advantage be used as an armature;" and in line 7 of page 18 I strike out the word "material" and insert in place thereof the words "equivalent plate;" and I strike out of the said page 18 the paragraph beginning with the words "If two," in line 23, and ending with the word "sound" in line 30,

2667

and I insert after the word and figure "and 26" in line 40 of the same page 18 the words "which is not claimed further than is indicated by the claims made in the claiming clauses hereunto annexed;" and after the word "invention" in line 47 of the same page 18 I insert the words "to which no claim is made otherwise than in the "claiming clauses hereunto annexed;" and I strike out the claiming clauses "First," "Second," and "Third" on page 20, beginning with the word "first" in line 28 of the same page 20 and ending with the words "set forth" in line 37; and I strike out the word "Fourth" in line 38 of the same page 20 and insert in place thereof the word "First;" and after the words "set forth" in the same line 38 I insert the words "and described respectively in the fourth and fifth plans above referred to, but subject always to the disclaiming notes;" and after the word "magnet" in the same line 38 I insert a parenthesis, and after the word "action" in line 39 I insert another parenthesis, so that the words in lines 38 and 39 of page 20 "or other body capable of inductive action" shall be within parenthesis; and I strike out the claiming clauses "Fifth" and "Sixth" on the said page 20, beginning with the word "Fifth" in line 46 of the same page, and ending with the words "set forth" in line 52; and I strike out the word "seventh" in line 53 of the same page 20 and insert in place thereof the word "second;" and after the word "current" in line 53 of the same page I insert the words "generated as described in the fourth and fifth plans, but subject always to the disclaiming notes;" and in line 56 of the same page 20 I strike out the word "eighth," and insert in place thereef the word "third," and after the word "current" in line 57 of the same page 20 I insert the words "generated as described in the fourth and fifth plans, but subject always to the disclaiming notes;" and I strike out the word "ninth" in line 3 of page 21, and insert in place thereof the word "fourth," and after the word "telephones" in line 3 of the same page 21 I insert the word "when;" and after the word "described" in the said line 3 of the same page 21 I insert the words "in the fourth and fifth plans, but subject always to the disclaiming notes;" and I strike out the word "tenth" in line 10 of the same page 21, and insert in place thereof the word "fifth;" and after the word "instruments" in line 11 of the same page 21 I insert the words "such as are described in the fourth and fifth plans, but sub-

2618

ject always to the disclaiming notes;" and in line 15 of the same page I strike out the word "instrument," and insert in place thereof the words "instruments such as are above mentioned;" and I strike out the word "eleventh" in line 18 of the same page 21, and insert in place thereof the word "sixth" and in the same line I strike out after the word "combination" the words "with an electro-magnet of," and insert in place thereof the words "in the manner described in the fourth and fifth plans, but subject always to the disclaiming notes of an electro-magnet with;" and I strike out the claiming clause beginning with the word "twelfth" in line 21 of the same page 21, and ending with the word "possible" in line 24 of the same page 21, and I strike out the word "thirteenth" in line 25 of the same page and insert in place thereof the word "seventh;" and after the word "described" in line 27 I insert the words "in the fourth and fifth plans but subject always to the disclaiming notes;" and I strike out the fourteenth and fifteenth claiming clauses on the same page 21, beginning with the word "fourteenth" in line 28 of the same page 21, and ending with the words "set forth in line 32 of the same page 21, and in line 33 of the same page I strike out the word "sixteenth;" and insert in place thereof the word "eighth;" and after the word described in line 35 of the same page I insert the words "in the fourth and fifth plans," but subject always to "the disclaiming notes," and I strike out the claiming clauses "seventeenth" and "eighteenth" on the said page 21, beginning with the word "seventeenth" in line 36 of the same page, and ending with the word "described" in line 48. And the said specification when so disclaimed, altered and amended (omitting formal parts and as printed by the Queen's printers) will read as follows:

"Specification in pursuance of the conditions of the letters "patent filed by the said William Morgan-Brown in the Great "Seal Patent Office, on the 9th June, 1877.

"William Morgan-Brown, of the firm of Brandon & Morgan-"Brown, Engineers and Patent Agents, of 38, Southampton "Buildings, London, and 1 Rue Laffite, Paris: "Improvement "in Electric Telephony (transmitting or causing sounds for "telegraphing messages) and Telephonic Apparatus. A com-"munication from abroad by Alexander Graham Bell, of the "University of Boston, Massachussetts, United States of "America, Professor of Vocal Physiology.

2669

"This invention of improvements in electric telephony "(transmitting or causing sounds for telegraphing messages) "and telephonic apparatus relates to electric telephony and "telephonic apparatus, as hereinafter described, and claimed "in the claiming clauses hereunto annexed.

"This present invention relates to the reproduction by the "necessary receiving instruments of any particular sounds or "combinations of sounds through the agency of an electric cur- "rent, whereby articulate speech may be electrically trans- "mitted.

"The invention also relates to the electrical production or "transmission, in the manner hereinafter described and claimed, "of sounds of every kind by means of undulatory currents of "electricity, whereby not only musical sounds but articulate "speech can be transmitted over a telegraph line.

"The invention also relates to the electrical production or "transmission, in the manner hereinafter described and claimed, "of sounds of every kind without a battery being used in the "main circuit, or used otherwise than in the manner hereinafter "described and claimed by means of undulatory currents of "electricity, whereby not only musical notes but articulate "speech can be transmitted over a telegraph line.

"First plan, to which no claim is made otherwise than in the "claiming clauses hereunto annexed.

"The first method of an apparatus for transmitting two or "more telegraphic messages or signals simultaneously along a "single wire by the employment of transmitting instruments, "each of which occasions a succession of electrical impulses "differing in rate from the others, and of receiving instru- "ments, each tuned to a pitch at which it will be put in vibra- "tion to produce its fundamental note by one only of the "transmitting instruments, as devised by my communicator, is "illustrated in figures 1 and 2 of sheet 1, and in figures 3, 4, "and 5 of sheet 2.

"The transmitting instrument T (figure 1) consists of an "electro-magnet *e*, having a steel spring armature *a*, which is "kept in continuous vibration by the action of a local battery "*b*. The armature *a* in the course of its vibration brings the "platinum rivet *r* alternately into contact with two platinum "points, *l* and *m*, one, *l*, being placed in a local circuit *b*, s^2,

2670

" l, r, s^3, b, and the other m, communicating with the line wire " W through the screw cap s^1.

" The receiving instrument R, shown in plan in figure 1, " and in elevation in figure 2, consists of an electro magnet E " having a coil upon only one of its legs. A steel spring arma- " ture A is firmly clamped by one extremity to the uncovered " leg of the electro-magnet E, and its free end is allowed to " project above the pole of the covered leg. Upon depressing " the key K (figure 1) a communication is established between " the main battery B and the vibrating armature a of the trans- " mitter T. When the rivet r touches the point m the main cir- " cuit is completed. The currents of z pass to the ground at " G, and the currents of c pass through K, s, r, m, s^1 to the line " wire W, and thence through the electro-magnet E of the re- " ceiver R to the ground at G^1. When the rivet r leaves the " point m the main circuit is broken. So long then as the key " K is depressed the vibration of a occasions an intermittent " action of the current from the battery B upon the line wire " W and the armature A of the receiver R is attracted in an " intermittent manner by its electro-magnet E.

" When the makes and breaks of the circuit at m, r are " timed to the normal movements of the armature A of the re- " ceiving instrument, that is, when A is tuned to yield the same " musical pitch as the armature a of the transmitting instru- " ment, then the armature A is thrown into strong vibration, " thereby causing it to emit its musical note.

" When the key K is raised the communication between the " main battery B and the transmitter T is cut off and A be- " comes silent. So long as the key K is depressed a musical " note is emitted by A, and the duration of this note can be " made to signify the dot or dash of the Morse alphabet; thus " a telegraphic dispatch can be sent from T to R by manipu- " lating the key K in the usual manner.

" Figures 3, 4 and 5, sheet 2, illustrate the combination of " these instruments upon a telegraphic circuit so as to permit " the similtaneous transmission of a number of telegraph mes- " sages along a single wire.

" The armature of the transmitters and receivers that are " numbered alike at all the stations have the same pitch; thus " the transmitter T^2 of the figure 3 is the unison of the " transmitter T^2 at the station represented in figure 4, and

2671

" also of the receiver R^2 at the stations shown in figures 3, 4
" and 5.

" The sounds produced by the transmitters T, T^1, T^2, &c.,
" differ in pitch from one another, and are so arranged that each
" transmitter can effect one and one only of the receiving in-
" struments R, R^1, R^2, &c., at each station upon the line.

" To illustrate the operation of this form of the invention,
" depress any key, say key K^1, figure 3, a communication being
" thereby established between the main battery 3 and the trans-
" mitting instrument T^1, an intermittent current passes on to
" the main line through the receiving instruments R, R^1, R^2,
" &c., of figures 3, 4 and 5, to the earth at G, figure 5. The re-
" ceiving instruments R^1, figures 3, 4 and 5 respond, so long as
" the key K^1, figure 3, is depressed, and become silent the mo-
" ment it is raised. The other instruments R, R^2, &c., at sta-
" tions, figures 3, 4 and 5, remain silent, so that a telegraphical
" message transmitted by the manipulation of key K^1, figure 3, is
" received upon only its corresponding receiving instrument at
" each station toward that station, herein shown as figure 5,
" where the receiving instruments are connected directly with
" the earth.

" The instruments shown in figure 4 operate as just described
" for those of figure 3, the depression of each key K, K^1, or
" K^2, &c., operating those receiving instruments in stations 4
" and 5, that are in unison with the transmitting instrument
" connected with the key, but does not affect the instruments in
" figure 3, or in that direction.

" To illustrate the simultaneous transmission of telegraphic
" messages by these instruments, an operator in the station,
" shown in figure 3, is supposed to manipulate the key K, while
" at the same time another operator in station, figure 4, is trans-
" mitting an entirely different despatch by the manipulation of
" the key K^1. The signals produced by the depression of key
" K, figure 3, are received by the receivers R of figures 3, 4 and
" 5, and the signals due to the manipulation of the key K^1,
" figure 4, affect the receiving instrument R^1 of figures 4 and 5,
" but not R^1 of figure 3, or of any station in the direction of
" figure 3; hence, although upon this plan two or more mes-
" sages may be sent simultaneously over the same circuit from
" the same or different stations to the same or different stations,
" still as the signals pass only in one direction, two line wires

2673

"are required to complete communication in both directions. "Intermittent currents adapted to work these instruments may "be produced without actually making and breaking the cir- "cuit, as hereinbefore described, by suddenly increasing and "diminishing the intensity of the current. Such currents are "termed for the sake of distinction 'pulsatory.' Intermittent "and pulsatory currents may be of two kinds, accordingly as "the electric impulses have all the same polarity, or are alter- "nately positive and negative. In the former case they are "termed 'direct,' in the latter, 'reversed' currents. These dis- "tinctions are graphically illustrated in figures 6 and 7.

"Second plan, to which no claim is made otherwise than in "claiming clauses hereunto annexed.

"In order to secure communication in both directions upon "a single circuit, this second plan was devised, and it is illus- "trated in figures 8, 9 and 10. In these figures the instru- "ments employed are similar to those shown in figures 1, 2, 3, "4 and 5, and like instruments are denoted by like letters; but "instead of connecting the transmitting instruments T, T^1, T^2, "&c., directly with the receiving instruments R, R^1, R^2, &c., "as in figures 3, 4, &c., they are connected with the primary "wires of an induction coil I, of usual construction, and the "currents induced in the secondary wires of the coil are direct- "ed to the receiving instruments R, R^1, R^2, &c., on the line "wire. By this arrangement the receiving instruments at the "terminal stations, figures 8 and 10, are connected directly with "the earth at G, and the signals made at any one station ap- "pear at 11, the stations on the circuit. On this plan, there- "fore, two or more messages may be sent simultaneously over "a signal circuit in the same or in an opposite directions.

"Third plan, to which no claim is made otherwise than in "the claiming clauses hereunto annexed.

"In the methods heretofore described, employing intermit- "tent currents of electricity, the limit to the number of signals "that can be sent simultaneously over the same wire is very "speedily reached, for when a number of transmitting instru- "ments having different rates of vibration are simultaneously "making and breaking the same circuit, the effect upon the "main line is practically equivalent to one continuous current. "In addition to this objection local and main batteries are re- "quired at every station on the line. Similar difficulties are

"experienced in employing pulsatory currents. To obviate
"these difficulties the plan of using an undulatory current of
"electricity, as described in this part of the invention, was de-
"vised.

"It has long been known that when a permanent magnet is
"caused to approach the pole of an electro-magnet a current
"of electricity is induced in the coils of the latter, and that
"when it is made to recede a current of opposite polarity to
"the first appears upon the wire. When, therefore, a perma-
"nent magnet is caused to vibrate in front of the pole of an
"electro-magnet an undulatory current of electricity is induced
"in the coils of the electro-magnet, the undulations of which
"correspond in rapidity of succession to the vibrations of the
"magnet in polarity to the direction of its motion, and in in-
"tensity to the amplitude of its vibration, or rather to the
"velocity of its motion. A current of this character is graphi-
"cally represented in line 3, figure 7, sheet 1. When the per-
"manent magnet is caused to vibrate in front of the pole of an
"electro-magnet, which is placed in circuit with a voltaic bat-
"tery, the undulatory current induced by the vibration of the
"permanent magnet is superposed upon the voltaic current.
"When the induced impulse is of similar polarity to the voltaic
"currents it serves to strengthen the intensity of the latter, but
"when it is of opposite polarity it tends to neutralize the vol-
"taic current. In such an arrangement the resultant effect of
"the vibration of the permanent magnet is to throw the bat-
"tery currents into waves, as in line 3, figure 6, by alternately
"increasing and diminishing the intensity of the current. Such
"increase and diminution in the intensito of the current does
"not take place with the suddenness characteristic of a pulsa-
"tory current (see line 2, figure 6), but is proportional to the
"increase and diminution of the density of the air during the
"vibration of the inducing body; the various kinds of electrical
"currents denominated intermittent, pulsatory and undulatory
"are graphically represented in figures 6 and 7. In figure 6
"the currents are direct, that is, the electrical impulses b^2, b^2,
"b^2, &c., are all of the same polarity, either positive or nega-
"tive, and in figure 7 the currents are reserved, that is, the
"electrical impulses are alternately positive and negative.

"Direct intermittent current (shown in line 1, figure 6). The
"impulses b^2, b^2, &c., are all of positive or all of negative elec-

2674

" tricity, and the vertical thickness of the lines b^2, b^2, &c.,
" measured from the zero line z^1, z^1, represents the intensity
" of the current of the part observed. The horizontal exten-
" sion of the line b^2 indicates the duration of the electrical
" impulse, and the horizontal extension of the space f^2 shows
" the length of time the current is absent from the circuit.

" Reversed intermittent current (shown in line 1, figure 7).
" Impulses of positive electricity are represented above, and
" impulses of negative electricity below, the zero line z^1, z^1, and
" the impulses b^2, d^2, are respectively positive and negative, or
" *vice versa*.

" Direct pulsatory current (shown in line 2, figure 6). The
" current of electricity represented is continuous, but it changes
" suddenly in intensity, the elevations b^2, d^2, &c., indicating
" the impulses of maximum intensity, and the depressions c^2, c^2,
" the impulses of minimum intensity. As before, the vertical
" thickness of the line indicates the strength of the current.

" Reversed pulsatory current (shown in line 2, figure 7). The
" impulses b^2, d^2, are alternately positive and negative without
" any break in the continuity of the current.

" Direct undulatory current (shown in line 3, figure 6). As
" before, the vertical thickness of the line represents the
" strength of the current, the elevations b^2, b^2, &c., express the
" impulses of maximum intensity, and c^2, c^2, &c., those of mini-
" mum intensity. The changes of intensity, as illustrated in
" line 3, do not occur with the suddenness characteristic of
" pulsatory currents, as shown in line 2, but are proportional to
" the changes in the density of the air during the production
" of a sound.

" Reversed undulatory current (shown in line 3, figure 7).
" The elevation b^2, b^2, &c., indicate impulses of positive and
" the depressions d^2, d^2, impulses of negative electricity, the
" vertical thickness of the portions b^2, d^2, indicating the
" intensity of the positive or negative impulse at the part ob-
" served. The oscillations of the current above and below the
" zero line correspond to the increase and diminution of the
" density of the air during the production of a sound, hence the
" elevations b^2, b^2, &c., correspond to condensation of air, and
" the depressions d^2, d^2, &c., to rarefactions, the intensity of the
" positive or negative impulses being proportioned to the
" degree of density or rarity of the air.

"The differences between intermittent pulsatory and undula-
" tory currents will be more clearly understood by describing
" and illustrating the condition of the electrical current when
" the attempt is made to transmit two musical notes simultane-
" ously, first upon one plan, and then upon the others. Let the
" interval between the two sounds be a major third, then their
" rates of vibration are in the ratio of 4 to 5. Now, when an
" intermittent current is used, the circuit is made and broken
" four times by the armature *a*, figure 11, sheet 1, of one trans-
" mitting instrument in the same time that five makes and
" breaks are caused by the armature a^1 of the other transmit-
" ting instrument; A^2 and b^2, figure 11, represent the inter-
" mittent currents produced, four impulses of B^2 being made in
" the same time as five impulses of A^2, b^2, b^2, &c., figure 11,
" show where and for how long time the circuit is made, and
" f^2, f^2, &c., indicate the duration of the breaks of the circuit.
" The line A^2+B^2, shows the total effect upon the current when
" the armatures *a*, a^1, figure 11, are caused simultaneously to
" make and break the same circuit, and the combined effect
" upon the current passing through the receiver R, shown at
" A^2+B^2, figure 11, is very nearly equivalent to a continuous
" current.

" When many transmitting instruments, of different rates of
" vibration, are simultaneously making and breaking the same
" circuit, the current upon the main line becomes, for all prac-
" tical purposes, continuous.

" When the armature, *a*, a^1, are arranged upon circuit, as
" shown in figure 12, pulsatory currents traverse the coils of
" the receiving instrument, R. The line A^2 represents the pul-
" satory current due to the action of one armature *a*, and the
" line B^2 the action due to the other armature a^1; b^2 b^2, &c.,
" represent impulses of maximum intensity, and c^2, c^2, &c., im-
" pulses of minimum intensity. Four impulses of B^2 are made
" in the same time as five impulses of A^2, and the line A^2+B^2
" represents the total effect upon the current passing through
" the coils of the receiver R when the armature *a* and a^1 are
" caused to vibrate simultaneously. This effect is nearly equiv-
" alent to a continuous current of minimum intensity.

" Next consider the effect when undulatory currents are em-
" ployed. Electrical undulations, induced by the vibration of
" a body M, figure 15, capable of inductive action, can be rep-

"resented graphically by the same sinusoidal curve which ex-
"presses the vibration of the inducing body itself, for, as above
"stated, the rate of oscillation in the electrical current is the
"same as that in the inducing body. The intensity of each
"induced impulse is proportional to the velocity of the motion
"of the inducing body, and the polarity of each induced im-
"pulse depends upon the direction of the motion of the in-
"ducing body to or from the pole of its electro-magnet. The
"sinusoidal curves A^2 and B^2, figure 13, represent graphically
"the electrical undulations induced in a circuit by the vibra-
"tion of permanent magnets M and M^1, or other bodies capa-
"ble of inductive action.

"The portions b^2, b^2, &c., represent impulses of positive
"electricity, and d^2, d^2, &c., impulses of negative electricity.
"The horizontal line z^1, z^1, represents the zero of current, and
"the vertical distance of any portion of the curve b^2 or d^2
"from the zero line expresses the intensity of the positive or
"negative impulse at the part observed.

"The vibrations represented by the sinusoidal curves B^2 and
"A^2, figure 13, are in the ratio aforesaid of four to five, that is,
"four oscillations of B^2 are made in the same time as five oscil-
"lations of A^2. The combined effect of A^2 and B^2, when induced
"simultaneously on the same circuit, is expressed by the curve
"A^2+B^2, figure 13, which is the algebraical sum of the sinu-
"soidal curves A^2 and B^2, in figure 14; the permanent mag-
"nets M and M^1 are caused to vibrate in front of the poles of
"electro-magnets e, e^1 placed in circuit with the battery B;
"by such an arrangement the battery current is thrown into
"waves. The lines A^2 and B^2 represent the undulatory cur-
"rents produced respectively by the vibrations of M and
"M^1, and, as in the other instances, four impulses of B^2 are
"made in the same time as five impulses of A^2; the elevations
"b^2 b^2 &c., indicate impulses of maximum intensity, and the
"depressions c^2 c^2, &c., impulses of minimum intensity; the
"vertical distance or any portion of the curve b^2 c^2 from the
"zero line z^1 z^1 expresses the intensity of the current at part
"observed; the line A^2+B^2 expresses the resultant effect upon
"the current when the permanent magnets M M^1 are caused
"simultaneously to vibrate; the curves A^2 B^2, figures 13 and
"14, also indicate the actual motion of the air when the two
"magnets M M^1 are vibrated simultaneously. Thus, when

"electrical undulations of different rates are simultaneously "produced upon the same circuit, the effect is exactly analo- "gous to that occasioned in the air by the vibration of the in- "ducing bodies. Hence the coexistence upon a telegraphic cir- "cuit of electrical undulations, corresponding to sounds of dif- "ferent pitch, is manifested, not by the obliteration of the "vibratory character of the current, as with intermittent and "pulsatory currents, but by peculiarities in the shapes of the "electrical undulations, or in other words by peculiarities "in the shapes of the curves which represent those undula- "tions.

"There are many ways of producing undulatory currents of "electricity dependent for effect upon the vibration or motion "of bodies capable of inductive action. A few of the methods "that may be employed are as follows: When a wire through "which a continuous current of electricity is passing is caused "to vibrate in the neighborhood of another wire, an undulatory "current of electricity is induced in the latter. When a cylin- "inder upon which are arranged bar magnets is made to rotate "in front of the pole of an electro-magnet, an undulatory cur- "rent of electricity is induced in the coils of the electro-mag- "net.

"Undulations are caused in a voltaic current by the vibra- "tion or motion of bodies capable of inductive action, or by the "vibration of the conducting wire itself in the neighborhood of "such bodies. Electrical undulations may also be caused by "alternately increasing and diminishing the resistance of the "circuit, or by alternately increasing and diminishing the "power of the battery. The internal resistance of a battery is "diminished by bringing the voltaic elements nearer together, "and increased by placing them farther apart; the reciprocal "vibration of the elements of a battery therefore occasions an "undulatory action in the voltaic current.

"The external resistance may also be varied; for instance, "let water, or some other liquid of high resistance, form part "of a voltaic circuit; then the more deeply the conducting "wire is immersed in the water or other liquid the less resist- "ance does the liquid offer to the passage of the current; hence "the vibration of the conducting wire in water or other liquid "included in the circuit occasions undulations in the current. "The vertical vibration of the elements of a battery in the

2678

" liquid in which they are immersed produces an undulatory " action in the current by alternately increasing and diminish- " ing the power of the battery.

" In illustration of one method of creating electrical undu- " lations a form of apparatus is shown in Fig. 15. It is prefer- " able to employ for this purpose an electro-magnet E, Fig. 15, " having a coil upon only one of its legs. A steel spring arma- " ture A is firmly clamped by one extremity to the uncovered " leg *h* of the magnet, and its free end is allowed to project " above the pole of the covered leg. The armature A can be " set in vibration in a variety of ways, one of which is by wind, " and in vibrating it produces a musical note of a certain " definite pitch.

" When the electro-magnet E is placed in a voltaic circuit " B, E, W, E^1, B, the armature A becomes magnetic, and the " polarity of its free end is opposed to that of the magnet un- " derneath. So long as the armature A remains at rest no " effect is produced upon the voltaic current, but the moment it " is set in vibration to produce its musical note a powerful " inductive action takes place and electrical undulations traverse " the circuit above described. The undulatory current pass- " ing through the coil of the electro-magnet E^1 causes " vibration in its armature A^1 when the armatures of the two " magnets are normally in unison with one another, but the " armature A^1 is unaffected by the passage of the undulatory " current when the pitches of the two armatures are different.

" The instruments shown in Fig. 15 are like in plan to the " receiving instruments R, R^1, &c., of figures 1, 2, 3, 4, 5, 8, " 9, 10. A number of instruments may be placed upon a tele- " graphic circuit, as in figures 16, 17, 18. When the armature " of any one of the instruments is set in vibration, all the other " instruments upon the circuit which are unison with it respond, " but those which have normally a different rate of vibration " remain silent. Thus if R, Fig. 16, is set in vibration, the " armature of the receiver R, Figs. 17, 18, vibrate also, but all " the others on the circuit remain still. So if R^1, Fig. 17, is " caused to emit its musical note, the instruments R^1, shown in " Figs. 16 and 18, respond. They continue sounding so long " as the mechanical vibration of R^1, Fig. 17, is continued, but " become silent with the cessation of its motion. The duration " of the sound may be used to indicate the dot or dash of the

" Morse alphabet, and thus a telegraphic despatch may be in-
" dicated by alternately interrupting and renewing the sound.

" When two or more instruments of different pitch are simul-
" taneously caused to vibrate, all the instruments of corre-
" sponding pitches upon the circuit are set in vibration, each
" responding to only that instrument used as a transmitter with
" which it is in unison. Thus the signals of R, Fig. 16, are re-
" peated by R, of Figs. 17 and 18, but by no other instrument
" upon the circuit. The signals of R^1, Fig. 18, by R^1, Figs. 16
" and 17, and the signals of R^2, Fig. 17, by R^2, Figs. 16 and 18,
" whether R, Fig. 16 R^1, Fig, 18, and R^2, Fig. 17, are succes-
" sively or simultaneously caused to vibrate. Hence by these
" instruments two or more telegraphic signals or messages may
" be sent simultaneously over the same circuit without inter-
" fering with one another, a single battery B being used for the
" whole ciruit. These instruments may be used for the simul-
" taneous transmission of musical notes differing in loudness as
" well as in pitch.

" When the armature A, figure 15, is set in vibration the ar-
" mature A^1 responds not only in pitch but in loudness. Thus
" when A vibrates with little amplitude, a very soft musical
" note proceeds from A^1, and when A vibrates forcibly, the
" amplitude of the vibration of A^1 is considerably increased, and
" the resulting sound becomes louder. So if R and R^1, figure
" 16, are sounded simultaneously (R loudly and R^1 softly) the
" instruments R, figures 17 and 18, repeat loudly the signals
" of R, figure 16, and R^1, figures 17 and 18, repeat softly those
" of R^1, figure 16."

" FOURTH PLAN.

" Which is not claimed further than is indicated by the
" claims made in the claiming clauses hereunto annexed, and it
" is to be noted that no claim is made to the use of telephonic
" apparatus, wherein a membrane like gold beaters' skin is used
" in combination with an electro-magnet excited by a battery
" which is arranged in the main circuit or line wire, inasmuch
" as such a membrane was mentioned in descriptions published
" in England prior to December 9, 1876, and as such a mem-
" brane is of small utility owing to its uncertainty of action
" caused by changes due to wear or moisture, or atmospheric
" influences.

2180

" In the plans so far described a separate instrument is em-
" ployed for every pitch, and the electric vibrations for different
" pitches are combined upon the wire, each armature being
" capable of transmitting or receiving but a single note, and
" thus as many separate instruments are required as there are
" messages or musical notes to transmit.

" In this part of the invention a single instrument is em-
" ployed, the armature of which can be set in vibration by a
" musical instrument, or by the tones of the human voice or by
" any sound whatever.

" This fourth plan is represented in figures 21, 22 and 23,
" wherein is shown a single telephone at each station in place
" of the transmitting and receiving instruments heretofore de-
" scribed, the telephones being illustrated separately in figures 19
" and 20.

" One of the ways in which the armature A, figure 15, may
" be set in vibration has been stated to be by wind. Another
" mode is shown in figure 19, whereby motion can be imparted
" to the armature by the human voice, or by means of a musical
" instrument or by sounds of any kind.

" The armature A, figure 19, is fastened loosely by one ex-
" tremity to the uncovered leg *h* of the electro-magnet, E, and
" its other extremity is attached to the centre of a stretched
" membrane *n*. A cone C^2, is used to converge sound vibra-
" tions upon the membrane. When a musical note is made in
" the neighborhood of the membrane *n* it is set in vibration, the
" armature A is forced to partake of the motion, and thus elec-
" trical undulations are created upon the circuit G, B, E. W,
" E^1, G^1. The armature A^1 is thus thrown into synchronous
" vibration with the armature A, emitting a musical note of
" similar pitch to that which originated the vibration of arma-
" ture A. If two or more musical notes be simultaneously
" sounded in the neighborhood of the cone C^2, the resultant
" motion of the air is copied by the membrane *n* to which the
" armature A is attached and this armature A, acting induct-
" ively upon the current traversing the coils of the electric mag-
" net E, occasions an increase and diminution in its intensity,
" and the armature A^1 is thrown into vibration by the varying
" attraction of the electro-magnet E^1 to which it is attached,
" and thus imparts to the air at n^1 a fac-simile copy of the mo-
" tion of the air that acted upon the membrane *n*; hence two

" or more musical notes or telegraphic messages can be sent
" simultaneously along a single circuit from one station to
" another by means of one instrument at each station.

" Instead of the cone membrane and armature shown in fig-
" ure 19, a plate of thin steel, such as is shown at A^3, in figure
" 31 of the drawings hereunto annexed, may with greatly in-
" creased advantage be used as an armature; the vibrations of
" the plate in front of the magnet occasioned by the motion of
" the air during the production of a sound changes the inten-
" sity of the current as hereinbefore described, and occasions a
" similar motion in a similar steel plate in front of another elec-
" tro-magnet at another station in the circuit. Such a plate is
" shown in figure 20 and marked A^3, it being attached to a
" frame F. The telephones shown in figures 21 to 26 are of
" the kind shown in figure 20. This invention is not limited
" however, to the use of a steel plate, but includes within its
" scope any equivalent plate capable of inductive action upon a
" current of electricity. In this plan an operator at station,
" figure 21, may send a telegraphic message on a certain pitch
" while another operator at another station, say figure 22, is
" transmitting another message on a different pitch, and both
" sounds will be audible at all the stations in the circuit.

" The receiving operator will pay attention to signals of only
" one pitch; hence, by this plan the simultaneous transmission
" of a number of telegraphic messages over a single circuit, and
" in the same or both directions, with a single main battery for
" the whole circuit, and a single telephonic instrument at each
" station is rendered possible. Whatever sound is made in the
" neighborhood of any telephone, say, T, *e*, figure 21, is echoed
" in facsimile by the telephones T, *e*, of all the other stations;
" hence, this fourth plan is also adapted for the entirely new
" use of transmitting intelligibly the exact sounds of articulate
" speech.

" To convey an articulate message, it is only necessary for
" the operator to speak in the neighborhood of a telephone, say
" T, *e*, figure 21, and for the receiving operator at another in-
" strument, say, T, *e*, figure 23, to listen.

" All the methods of producing undulatory currents of elec-
" tricity hereinbefore described may be employed in producing
" the undulations by which to transmit articulate messages.
" For instance, the vibrations of a membrane may cause a pla-

" tinum wire to vibrate in water or other liquid of high resist-
" ance included in the circuit, and hence will occasion changes
" in the intensity of the current, traversing the circuit propor-
" tional to the changes in the density of the air, which originally
" gave rise to the vibrations of the membrane, and hence the
" sounds uttered in the neighborhood of that membrane will be
" reproduced from a telephone on a distant part of the circuit.

" In the fifth plan of the invention, illustrated in figures
" 24, 25, and 26, which is not claimed further than is indicated
" by the claims made in the claiming clauses hereunto annexed,
" the battery is omitted and a permanent magnet M^3 is sub-
" stituted for the soft iron core of the electro-magnets used in
" the other telephones, or the coils shown in figures 24, 25 and
" 26, may be induction coils of usual construction, local bat-
" teries being placed in circuit with the primary wires, so as to
" magnetize the soft iron cores of the coils. The undulations
" induced in the secondary wires by the vibration of the plates
" A^3 being directed upon the line wire.

" The sixth plan of the invention, to which no claim is
" made otherwise than in the claiming clauses hereunto an-
" nexed, is represented in figures 27, 28 and 29. Figure 27
" being a side view of the receiving instrument R, having a
" magnet E and armature A, as before described, and provided
" also with a vibratory circuit breaker V. This circuit breaker
" is designed for the purpose of enabling the armature A to
" open or close a local circuit through the medium of the cir-
" cuit breaker V. This circuit breaker consists of a light metal-
" lic lever, normally resting upon the point 5, preferably ad-
" justed, so as to close a local circuit. The extremity of the
" circuit breaker overhangs the free end of the armature A.
" When the armature A is thrown into vibration by the action
" of magnet E, the circuit breaker is lifted from the point 5,
" and it does not return until the cessation of the vibration of
" the armature A.

" In figure 28 an arrangement is shown whereby the lifting
" of the circuit breaker V opens a local circuit in which is
" placed a Morse sounder 6 or other electrical apparatus.

" In figure 29 the circuit breaker V normally 'short cir-
" cuits' the battery B, cutting off the current from the Morse
" sounder 6 or other apparatus, so that the lifting of the cir-
" cuit breaker V permits the current from the battery B to

1683

" actuate telegraphic instrument 6. The vibrating circuit
" breaker V may be changed in construction, it only being nec-
" essary that it have normally a slower rate of vibration than
" the armature A by which it is vibrated.

" Figure 30 represents an arrangement of transmitting in-
" struments T, T^1, T^2, &c., and receiving instruments R, R^1, &c.,
" and vibratory circuit breakers V, V^1, &c., similar to those
" shown in figures 1, 2, 27, designed to produce automatically
" at the receiving end of the line a facsimile of whatever char-
" acters or marks are presented at the transmitting ends. In
" this plan the messages or marks to be copied may be written
" or printed in non-metallic ink on a metallic surface F, *o*,
" shown in dotted lines (preferably tin foil), or impressed upon
" the same. This metallic surface is placed upon a suitable
" metallic support S, preferably made as a roller, having its axis
" at 7 connected with the battery B and the earth G. At the
" receiving end a similar support S^1 is connected in circuit with
" the battery B^1 and the vibratory circuit breakers V, V^1, V^2, &c.,
" and on this support is placed a piece or strip of chemically
" prepared paper P, *a*, shown in dotted lines.

" The metallic surface F, *o*, on which is written the message
" to be transmitted is moved between the support S and the
" ends of a series of wires 8, 9, 10, 11, 12, 13, &c., such ends
" being held by a non-metallic holder or bar 14. The wires 8,
" 9, 10, &c., communicate with the armatures *a* of transmitters
" T, T^1, &c., similar to the transmitter T, shown in figure 1.

" At the receiving end of the circuit the ends of a similar ar-
" rangement of wires 15, 16, 17, 18, 19, and 20 are held in place
" by a non-metallic holder 21, so as to rest upon the chemically
" prepared paper P *a*.

" The metallic surface, F *o*, and the chemically prepared
" paper, P *a*, are each moved in the direction of the arrows
" under their respective series of wires, but not necessarily at
" equal speed, and the characters or marks on the foil are
" copied on the prepared paper.

" When the end of any of the wires at the transmitting
" end, say wire 8, rests upon the metallic foil, a communication
" is established between the battery B and the armature *a* of
" the transmitter T; the platinum rivet *r*, as before described,
" vibrates and makes and breaks contact with the point *m*, so
" that an intermittent current of electricity appears upon the

" line wire W. So long then as the wire 8 rests on the metallic
" surface F *o*, the currents of *c* pass through 7, 8, S F *o*, 8, *r*,
" *m*, to the line wire W, and thence by branches through the
" receiving instruments R, R^1, &c., to the earth at G^1.

" The armature of the receiving instrument R, which is in
" unison with the armature *a* of the transmitter T, is thrown
" into vibration by the passage of the intermittent current but
" the armatures of the other transmitting instruments R^1, R^2,
" &c., having a different rate of vibration from the armature of
" T. do not respond.

" The armature of the receiving instrument R in the course
" of its vibration lifts the spring lever V, breaking the circuit
" B^1, S^1, P *a*, 15, V, B^1. So long then as the end of the wire
" 8 rests upon the metallic surface F *o*, the local circuit in
" which the wire 15 is placed remains open, and thus no mark
" is made upon the paper P *a*, under wire 15.

" When, during the movement of the metallic surface F *o*, a
" portion of the non-metallic ink comes under the end of the
" wire 8 the connection between the battery B and transmitter
" T is broken, the receiver R becomes silent, the spring lever V
" returns to its normal position, closing the circuit above
" described, and a mark is made upon that part of the chemi-
" cally prepared paper P *a*, under wire 15.

" Each wire 9, 10, &c., operates in a like manner to the wire
" 8, and the wires 16, 17, 18, &c., operate as described for
" wire 15.

" Any of the ordinary chemically prepared paper used in
" connection with ordinary systems of chemical or autograph
" telegraphs may be used.

" Referring again to the fifth plan, the magnet may be of the
" horseshoe form as shown at 24, in Fignre 31, and the coils of
" of the insulated wire 25 may surround soft iron cores or pole
" pieces 26 screwed or otherwise, fastened to the ends of the
" magnet 24. The cores or pole pieces are placed near the face
" of the metallic plate A^3, it being attached to a cup-shaped
" block 28, having a central orifice, 29, for the reception of a
" speaking or hearing tube to convey sounds to or from the
" plate A^3.

" The magnet is attached to a stud, 30, adapted to be moved
" in suitable grooves in the base, 31, by means of a screw, 32,
" having its end connected with the stand, the body of the

" screw being fitted to turn in a screw threaded stud. The
" movements of the screw are just the distance between the
" pole of the magnet and the plate A^3, and permit the poles to
" be placed almost in contact with the plate. The coils may be
" placed about the end of the magnet 24, and the soft iron pole
" pieces be omitted.

" Figure 32 represents in perspective a telephone of the kind
" shown in Figure 31, when placed within a sounding box 33.
" The coils will, perferably, be very thin and be placed at the
" extremity or extremi ies of the magnet. One, two or more
" magnetic poles with coils may be placed near a plate to in-
" tensify the effect.

" The soft iron core and coil may be attached to the plate
" instead of the magnet, or the core may be placed upon the
" plate and the coil on the magnet, or *vice versa* the magnet
" may be made to vibrate instead of the plate.

" Having now described and particularly set forth the na-
" ture of the said invention, and the manner of carrying the
" same into effect, I would have it understood that what I
" claim is :

" First. The combination, substantially as set forth and de-
" scribed respectively in the fourth and fifth plans above re-
" ferred to, but subject always to the disclaiming notes of a perma-
" nent magnet (or other body capable of inductive action) with
" a closed circuit, so that the vibration of the one shall occa-
" sion electrical undulations in the other or in itself; and this
" I claim whether the permanent magnet be set in vibration in
" the neighborhood of the conducting wire forming the circuit,
" or whether the conducting wire be set in vibration in the neigh-
" borhood of the permanent magnet, or whether the conducting
" wire and the permanent magnet, both simultaneously, be set
" in vibration in each other's neighborhood.

" Second. The method of transmitting vocal or other sounds
" electrically by causing the intensity of an electrical current
" generated as described in the fourth and fifth plans, but sub-
" ject always to the disclaiming notes to vary in a manner pro-
" portional to the variations of density produced in the air by
" the said sounds.

" Third. The method of transmitting vocal or other sounds
" electrically by causing the intensity and polarity of an elec-
" trical current generated as described in the fourth and fifth

"plans, but subject always to the disclaiming notes, to vary in "a manner proportional to the velocity and the direction of "motion of the particular air during the production of the "rounds.

"FOURTH. The union upon and by means of an electric cir- "cuit of two or more telephones when constructed for opera- "tion, substantially as described in the fourth and fifth plans, "but subject always to the disclaiming notes, so that if the "plate armature of any one of the said instruments be moved "in any manner the armatures of all the other telephones upon "the same circuit will be moved in a like manner; and if the "transmitter armature be moved or vibrated by sound, like "sounds will be produced by the motion or vibration of the "armature of the other telephones upon the circuit.

"FIFTH. In a system of electric telegraph or telephony, "consisting of transmitting and receiving instruments such as "are described in the fourth and fifth plans, but subject al- "always to the disclaiming notes, united upon an electric cir- "cuit, I claim the production in the armature of each receiving "instrument of any given motion by subjecting said armature "to an attraction varying in intensity, however such variation "may be produced in the magnet; and hence I claim the pro- "duction of any given sound or sounds from the armature of "the receiving instruments, such as are above mentioned, by "subjecting said armature to an attraction varying in intensity "in such manner as to throw the armature into that form of "vibration which characterizes the given sound or sounds.

"SIXTH. The combination in the manner described in the "fourth and fifth plans, and subject always to the disclaiming "notes, of an electric magnet with a plate of iron or steel or "other material capable of inductive action, which can be "thrown into vibration by the movement of surrounding air, or "by the attraction of a magnet.

"SEVENTH. In an electric telephone the combination with "the plate of a magnet having coils upon the end or ends of "the magnet nearest the plate, substantially as described in "the fourth and fifth plans, but subject always to the disclaim- "ing notes.

"EIGHTH. In an electric telephone the combination with "a permanent magnet and plate armature of a soft iron pole "piece forming the core for the coil, substantially as described

" in the fourth and fifth plans, but subject always to the dis-
" claiming notes.

" In witness whereof, I, the said William Morgan-Brown,
" have hereunto set my hand and seal, this twenty-fourth day
" of January, in the year of our Lord one thousand eight hun-
" dred and seventy-eight.

" WILLIAM MORGAN-BROWN. [L. S.] "

To the Commissioners of Patents for Inventions:

I hereby grant my fiat, giving leave to the above-named William Morgan-Brown to file in the Great Seal Patent Office with the specification to which the same relates, the above written disclaimer and memorandum of alteration.

JOHN HOLKER,
Attorney-General.

TEMPLE, 12th February 1878.

No. 77. Defendants' Exhibit, Specification of David Edward Hughes, Telegraphic Apparatus, &c.

J. A. W., Sp. Exr.

[Introduced in Case, p. 410.]

A. D., 1863, 27th January. No. 241.

TELEGRAPHIC APPARATUS.

Letters Patent to David Edward Hughes, of the United Kingdom Electric Telegraph Company (Limited), Gresham House, Old Broad Street, in the City of London, Electrical Engineer for the Invention of "Improvements in Means or Apparatus for Effecting Telegraphic Communications."

Sealed the 21st July, 1863, and dated the 27th January, 1863.

Provisional Specification left by the said David Edward Hughes at the Office of the Commissioners of Patents with his Petition on the 27th January, 1863.

I, DAVID EDWARD HUGHES, of the United Kingdom Electric Telegraph Company (Limited), Gresham House, Old Broad Street, in the City of London, electrical engineer, do hereby declare the nature of the said invention for "Improvements in Means or Apparatus for Effecting Telegraphic Communications," to be as follows:

The improvements relate, first, to means for regulating or governing the motion of apparatus employed when recording telegraphic communication. Upon one of the main axes of such apparatus I apply a fly or balance wheel, and opposite the end of this axis, but held somewhat inclined to it, I apply an elastic and weighted rod, capable of vibrating in a rotary direction when acted upon by an arm or connection from the main axis referred to. The vibrations thus obtained regulate and render uniform the motions of the apparatus without the necessity of an escapement. The position of the weight on the vibrating rod is capable of being regulated to the speed desired. To prevent breakage of this vibrating rod by the extent of its

vibrations, a pad or friction surface is brought into operation upon a friction band or surface as the vibrations increase in order to use up the surplus force exerted.

Secondly, the improvements relate to means for facilitating the ready change from one class or character of recorded sign or indication to another, as from letters to figures. For this purpose the periphery of the type wheel is arranged with the desired different signs thereon in alternate order, and this wheel is affixed to a hollow shaft or boss which receives the hollow shaft or boss of a correcting or adjusting wheel, having teeth on its periphery corresponding with those of one set of signs on the type wheel or the intermediate positions thereof. The outer end of an arm from the axis of the type wheel passes into a recess in a lever turning upon an axis carried by the correcting or adjusting wheel, and this lever is formed at its opposite ends with projections adapted respectively to fill up spaces opposite those between the teeth of the correcting or adjusting wheel. The pressing in of one end of this lever will cause the teeth of the correcting or adjusting wheel to be coincident with one set of signs on the type wheel, and the pressing in of the opposite end of the lever causes the type wheel to be moved partly round on its axis, so that the intermediate signs are then coincident with the teeth of the correcting or adjusting wheel. One or the other end of this lever is pressed inwards at the times desired to effect a change when the apparatus is set in motion by the passage of a current of electricity brought into operation by acting on one or the other of particular keys corresponding with the relative position of the type and correcting or regulating wheels.

The improvements relate, thirdly, when using the power of a permanent magnet in connection with an electro-magnet in manner of the character described in the Specification of Letters Patent, granted respectively to Joseph Camp Griffith Kennedy, bearing date the 11th of September, 1855, No. 2058, and to myself, bearing date the 27th of April, 1858, No. 938, and consist in connecting the armature through a small local battery to one wire of the electro-magnet, and in connecting the other wire of the electro-magnet with a stud or projection in position to be acted upon by the armature when that is raised. By these means, upon the passage of a current of electricity into the electro-magnet the armature is at once released, when the cur-

rent of electricity, in place of continuing through the coils of the electro-magnet, flows by way of the armature and through the local battery to the main wire, at the same time the tendency of the local battery is to restore the magnetism in the cores of the electro-magnet.

Also my improvements relate to levers k^2 of the character referred to in the latter specification of letters patent as granted to me. In such former specification the surface of such lever k^2 for operating on the pins of the circle is shown only to extend over a surface equal to that of two pins, and I now find it important for the purpose of insuring a sufficient flow of electricity for considerable length of wire, and, when working with high speeds, to the type wheel, that the duration of contact of the contact surface employed may be equal to the passage of three or more letters of the type wheel.

SPECIFICATION in pursuance of the conditions of the Letters Patent, filed by the said David Edward Hughes in the Great Seal Patent Office on the 27th July, 1863.

TO ALL WHOM THESE PRESENTS SHALL COME, I, David Edward Hughes, of the United Kingdom Electric Telegraph Company (Limited), Gresham House, Old Broad street, in the City of London, Electrical Engineer, send greeting:

Whereas, Her Most Excellent Majesty Queen Victoria, by her Letters Patent, bearing date the twenty-seventh day of January, in the year of our Lord one thousand eight hundred and sixty-three, in the twenty-sixth year of her reign, did, for herself, her heirs and successors, give and grant unto me, the said David Edward Hughes, her special licence that I, the said David Edward Hughes, my executors, administrators and assigns, or such others as I, the said David Edward Hughes, my executors, administrators and assigns should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands and the Isle of Man, an invention for "Improvements in Means or Apparatus for effecting Telegraph Communications," upon

2691

the condition (amongst others) that I, the said David Edward Hughes, my executors or administrators, by an instrument in writing under my, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said letters patent.

Now know ye, that I, the said David Edward Hughes, do hereby declare the nature of the said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof, that is to say :

The improvements relate, first, to means for regulating or governing the motion of apparatus employed when recording telegraphic communication. Upon one of the main axes of such apparatus I apply a fly or balance wheel, and opposite the end of this axis, but held somewhat inclined to it, I apply an elastic and weight rod capable of vibrating in a rotary direction when acted upon by an arm or connection from the main axis referred to. The vibrations thus obtained regulate and render uniform the motions of the apparatus without the necessity of an escapement. The position of the weight on the vibrating rod is capable of being regulated to the speed desired. To prevent breakage of this vibrating rod by the extent of its vibrations a pad or friction surface is brought into operation upon a friction band or surface as the vibrations increase, in order to use up the surplus force exerted.

Secondly, the improvements relate to means for facilitating the ready change from one class or character of recorded sign or indication to another, as from letters to figures. For this purpose the periphery of the type wheel is arranged with the desired different signs thereon in alternate order, and this wheel is affixed to a hollow shaft or boss which receives the hollow shaft or boss of a correcting or adjusting wheel, having teeth on its periphery corresponding with those of one set of signs on the type wheel, or the intermediate positions thereof. The outer end of an arm from the axis of the type wheel passes into a recess in a lever turning upon an axis carried by the correcting or adjusting wheel, and this lever is formed at its opposite ends with projections adapted respectively to fill up

spaces opposite those between teeth of the correcting or adjusting wheel. The pressing in one end of this lever will cause the teeth of the correcting or adjusting wheel to be coincident with one set of signs on the type wheel, and the pressing in of the opposite end of the lever causes the type wheel to be moved partly round on its axis, so that intermediate signs are then coincident with the teeth of the correcting or adjusting wheel. One or the other end of this lever is pressed inwards at the times desired to effect a change, when the apparatus is set in motion by the passage of a current of electricity brought into operation by acting on one or the other particular keys corresponding with the relative position of the type and correcting or regulating wheels.

The improvements relate, thirdly, when using the power of a permanent magnet in connection with an electro-magnet in manner of the character described in these specifications of letters patent, granted respectively to Joseph Camp Griffith Kennedy, bearing date the 11th of September, 1855, No. 2058, and to myself, bearing date the 27th of April, 1858, No. 938, and consist in connecting the armature through a small local battery to one wire of the electro-magnet, and in connecting the other wire of the electro-magnet with a stud or projection in position to be acted upon by the armature when that is raised. By these means, upon the passage of a current of electricity into the electro-magnet, the armature is at once released, when the current of electricity, in place of continuing through the coils of the electro-magnet, flows by way of the armature and through the local battery to the main wire, at the same time the tendency of the local battery is to restore the magnetism in the cores of the electro-magnet.

Also, my improvements relate, fourthly, to levers k^2 of the character referred to in the latter specification of letters patent as granted to me. In such former specification the surface of such lever k^2 for operating on the pins of the circle is shown only to extend over a surface equal to that of two contact pins, and I now find it important for the purpose of insuring a sufficient flow of electricity for considerable lengths of wire, and when working with high speeds to the type wheel, that the duration of contact of the contact surface employed may be equal to the passage of three or more letters of the type wheel.

But that the improvements may be better understood, I

2693

2696

will proceed, by the aid of the accompanying drawings, more fully to describe the same.

Description of the Drawings.

Figure 1 represents a side view, partly in section; figure 2 a plan view, and figure 3 an end view of parts arranged to the first part of my improvements.

a indicates parts of the framing; *b* a fly or balance wheel affixed on one of the main axes of the apparatus employed in recording telegraphic communications; and, supposing these improvements applied to apparatus such as described in the specification of letters patent granted to me, bearing date the 27th day of April, 1858, No. 938, such fly or balance wheel will represent the fly or balance wheel Z there referred to, as affixed on the axis i^1 of that apparatus, but this may be varied; *c* is an elastic rod, one end of which is fixed stationarily at c^1, whilst the other end passes through an eye d^1, attached to the piece of thick leather, or other suitable elastic material *d*, which is affixed to the boss *e* between the plates e^1 and e^2 affixed thereto, by which the end of the leather *d* carrying the eye d^1, will, when the apparatus is at rest, lie on the plate e^1, and when the apparatus is in motion the leather *d* will be restrained by the plate e^2. The boss *e* carries a pin or axis e^*, which turns in a hole formed for it in the end of the arm e^3 affixed to the axis i^1; *f* is a weight capable of sliding on the elastic rod *c*, and of being held in any desired position thereon by its being affixed to the rod f^1, to which is affixed the rack f^2, the teeth of which are taken into by the teeth of the pinion f^3, by which that rack is moved so as to move the weight *f* along the rod *c*. The boss *e* also supports the arms *g* and *h*; the arm *g* is furnished with a pad g^1 of cloth, leather, or other suitable material, which in the rotary vibrations of the outer end of the rod *c* is brought to bear against the inside of the stationary rim a^1 affixed to the framing *a*, and the arm *g* is drawn towards the flang a^1 by means of the spring h^1 acting on the arm *h*. By this means, as the fly or balance wheel *b* revolves, motion will simultaneously be given to the weight *f*, which, by acting on the rod *c*, and thence through the strap or band *d* upon the boss *e* and the friction arm *g*, will cause an increase of friction upon that arm, in pro-

269

portion to the amount of force exerted by the tendency to increase the arc of vibration of the rod *c*, resulting from any increase of motive power exerted upon the apparatus, by which the effect of such power will be rendered uniform. By altering the position of the weight *f* along the rod *c*, the number of vibrations of that rod in a given time will be varied, so as to regulate and render uniform the speed of the mechanism to which it is connected in relation to another or other instruments with which it may be desired such mechanism should work in unison.

Figs. 4 and 5 shew a slight modification of the parts for holding the loose end of the elastic rod *c*, by the substitution of a rigid or only slightly elastic piece of metal *d* for the flexible material already referred to, and the application of a friction spring e^4 affixed to the arm e^3 with its loose end pressing on the boss *e* with a tendency to retard its movement.

Fig. 6 shews a side view, Fig. 7 a front view, Fig. 8 a back view, and Fig. 9 a section of parts arranged according to the second head of the invention. *i* is a type wheel for printing telegraphic communications, in manner such as described in the specification of letters patent referred to or otherwise; but, according to my present improvements, the periphery of this wheel is formed alternately into signs of a different character as letters and figures, and in place of this wheel being formed on or affixed to the same boss as that to which the correcting or adjusting wheel is affixed, as explained in the said specification of letters patent granted to me, the type wheel *l* is affixed to the tube or hollow axis i^1, which receives upon it the boss j^1 of the correcting or adjusting wheel *j*. To this hollow axis i^1 of the type wheel *i* is also affixed the lever of arm i^2, the outer end of which is received into a recess, as shewn in the lever i^3, which is capable of moving on its axis of motion i^4, carried by the correcting or adjusting wheel *j*. The effect of a depression of either end of this lever i^3 towards the centre of the wheel *j* is to cause the type wheel *i* to make a slight movement on its axis in relation to the correcting or adjusting wheel *j*, in a direction dependent upon which end of the lever i^3 is depressed, and the amount of movement thus obtained is equal to the distance between one sign and the next, or from one character of sign to the other on the type wheel, and the depression of one or the other end of the lever

i^3 is obtained by causing the cam or tappet k to act at the time desired, in manner such as described in respect of the tappet i^5 of the said former specification of letters patent granted to me, and for this purpose I make use of two finger or releasing keys, one to cause the tappet k to act on one end of the lever i^3 and the other on the other end thereof, according to the direction of the change desired, as from figures to letters, or from letters to figures, or from one to any other sign.

Figure 10 shows by a diagram an illustration of the third part of my improvements. a represents a portion of a line wire; b the electro-magnet; c a wire passing therefrom to the axes c^1 of the contact maker in apparatus of the character of that referred to as being described in the said specification of letters patent granted to me, No. 938[5 8]; d is one of the finger keys, by which contact is obtained; and e is a wire therefrom to one pole of the main battery f, the other pole of which is by the wire g in connection with the earth plate h; i is the armature affixed to the lever i^1, which turns upon an axis i^2, and is by the wire j in communication with one pole of a small local battery k, the other pole of which is in metallic connection with the wire a by means of the wire l. m is a stud carried by one end of the lever n, which is capable of turning upon an axis n^1. The axis n^1 is by means of a wire p in metallic connection with the axis c^1 of the contact maker, and the stud m is in metallic contact with the armature i. When, from electricity being caused to flow through the line wire a, the armature i is repelled from contact with the electro-magnet b, the current of electricity, in place of continuing through the coils of the electro-magnet b, will flow by way of the armature i, and through the local battery to the main wire a. At the same time the tendency of the local battery is to restore the magnetism in the cores of the electro-magnet.

The fourth part of the improvements is shown by side view and plan at figures 11 and 12. The red lines indicate a circle of contact pins q, and l l indicates the extended surface of the lever k^2, adapted to be in contact with any one of the pins q, a period equal to the time of traversing the space occupied by four of such pins; m m is the insulating cam acting therewith to force back the contact pins q after each operation.

Having thus described the nature of my said invention and means by which the several improvements are carried into ef-

feet, I would have it understood that I do not confine myself to the precise details shown and described as 5, these may be varied without departing from the peculiar character of such improvements.

In witness whereof, I, the said David Edward Hughes, have hereunto set my hand and seal, this twenty-fourth day of July, in the year of our Lord one thousand eight hundred and sixty-three.

D. E. HUGHES. [L. S.]

(No. 78.) Defendants' Exhibit, Specification of Joseph Camp Griffith Kennedy, Electro-Magnetic Telegraphs, &c.

J. A. W., Sp. Ex'r.

A. D. 1855. No. 2058.

[Introduced in Case, p. 410.]

ELECTRO-MAGNETIC TELEGRAPHS.

Letters Patent to Joseph Camp Griffith Kennedy, of Saint James' street, Piccadilly, in the County of Middlesex, gentleman, for the invention of "Improvements in the mode of and apparatus for transmitting signals by the use of the electric current, part of which improvements is applicable to the regulating of machinery generally."

A communication.

Sealed the 11th December, 1855, and dated the 11th September, 1855.

Provisional specification left by the said Joseph Camp Griffith Kennedy, at the office of the Commissioners of Patents, with his petition, on the 11th September, 1855.

I, Joseph Camp Griffith Kennedy, of St James' street, Piccadilly, in the County of Middlesex, gentleman, do hereby declare the nature of the said invention for "Improvements in the mode of and apparatus for transmitting signals by the use of the electric current, part of which improvements is applicable to the regulating of machinery generally," to be as follows:

The object of this invention is to transmit printed communications with greater dispatch and by a more simple arrangement of mechanism than is at present employed.

In carrying out this invention, clock-work is employed for driving the machinism, and the motion of a portion of the mechanism is rendered intermittent by the detentive power of a permanent magnet. A series of spring levers, answering to the

movement of a set of stops, which indicate letters or signs, and are depressed by the operator are brought into a line with a row of pins, projecting from and arranged helically around a metal barrel, which receives a continuous rotation by means of clock-work. The same power also drives (at the same speed) the type wheel which prints the message sent.

At the stations which are to receive signals an electro-magnet is provided, the coils of which are in connection with the battery at the transmitting station. Above this magnet a permanent magnet is mounted, the same being hinged to a stand, and receiving a tendency, by means of a spring or otherwise, to rise when the attraction between it and the iron of the electro-magnet ceases, which will be the case while a current of electricity is traversing the coils. The rise of the permanent magnet on its hinge will release the arm of a crank axle, and allow that axle to revolve, a weighted cord being provided for the purpose of driving it. A connecting rod from the crank axle transmits motion to a rocking frame or lever which carries the platen. At every rotation, therefore, of the axle the platen is raised and pressed against the type wheel. A travelling band of paper, which passes between the type wheel and platen, takes the impression of the lowest type, the type having been previously inked by an inking roller revolving in contact with the type wheel. The connecting rod which is pendent from the crank axle, serves to rock a lever, which, by reason of its connection with the permanent magnet, will draw it down into contact with the soft iron of the electro-magnet, and the current ceasing, it will retain that position and thereby stop the printing operation. A repetition current will, however, establish the condition requisite for a repetition of the movement of the platen, and the letter or sign printed will correspond to the stop touched by the operator, and thus any message may be readily transmitted.

The frame carrying the set of spring levers which are actuated by the stops is connected with the opposite pole of the battery to that with which the electro-magnet is in connection. When the circuit is established, by the contact of one of the spring levers with a corresponding pin on the barrel or cylinder, the current passes from the electro-magnet coils to a spring lever, which, being alternately upon a conducting and non-conducting wheel mounted on the axle of the pin barrel (as

that barrel rotates) returns the current through the barrel to the spring levers to the battery.

For the purpose of shutting off those stations which are not intended to receive the message, a flanged wheel is mounted on the axle of the printing wheel, with notches in it, corresponding to a blank on the type wheel, and a given letter denoting the station. Upon this flange a spring bolt acts, and by its pressure stops the rotation of the wheel; but when the notch corresponding to the letter denoting the station is presented to the bolt, the bolt will be thrown by a cam on the crank axle, before mentioned, and entering the notch or clearing the flange, the wheel will be allowed to revolve, and the apparatus at that station will operate, but, owing to no notch being presented to the bolt at other stations, they will not receive the message.

In carrying out this invention, it is very important that the speed of rotation of the printing wheel and pin barrel should be adjusted to a great nicety. For this purpose the detent is actuated by a vibrating spring, the free end of which is weighted by a sliding weight or otherwise to ensure the proper speed of pulsation. This contrivance, it will be understood, is also applicable to the regulating of other mechanism.

SPECIFICATION in pursuance of the conditions of the Letters Patent, filed by the said Joseph Camp Griffith Kennedy in the Great Seal Patent Office on the 11th March 1856.

TO ALL TO WHOM THESE PRESENTS SHALL COME: I, Joseph Camp Griffith Kennedy, of St. James' street, Piccadilly, in the County of Middlesex, gentleman, send greeting:

WHEREAS, Her Most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the eleventh day of September, in the year of our Lord one thousand eight hundred and fifty-five, in the nineteenth year of her reign, did, for herself, her heirs and successors, give and grant unto me, the said Joseph Camp Griffith Kennedy, her special license that I, the said Joseph Camp Griffith Kennedy, my executors, administrators and assigns, or such others as I, the said Joseph Camp Griffith Kennedy, my executors, administrators and assigns,

2963

should at any time agree with, and no others, from time to time, and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands and Isle of Man, an invention for "Improvements in the mode of and apparatus for transmitting signals by the use of the electric current, part of which improvements is applicable to the regulating of machinery generally," being a communication from abroad, upon the condition (amongst others) that I, the said Joseph Camp Griffith Kennedy, by an instrument in writing under my hand and seal, should particularly describe and ascertain the nature of the said invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said letters patent.

Now, know ye, that I, the said Joseph Camp Griffith Kennedy, do hereby declare the nature of the said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement, reference being had to the drawings hereunto annexed, and to the letters and figures marked thereon; that is to say:

The object of this invention is to transmit printed communications with greater despatch and by a more simple arrangement of mechanism than is at present employed.

In carrying out this invention, clock-work is employed for driving the mechanism, and the motion of a portion of the mechanism is rendered intermittent by the detentive power of a permanent magnet.

In the accompanying drawings, Fig. 1, sheet I., shews in front elevation the improved electro-magnetic printing telegraph complete; Fig. 2, sheet II., is a plan view of the same; and Figs. 3, 4 and 5, sheet III., are sectional elevations, shewing the details of the apparatus. Before entering into a detailed description of the improved apparatus, I will first explain, by reference to the diagram, Fig. 7, sheet IV., the principle of its operation. In this diagram, A represents an electro-magnet, situate at the station to which a communication is to be sent. The coils of this electro-magnet are connected with the earth by a ground wire A*, and by a line wire B with the platinum plate of the

battery C, which is situate at the station from whence the message is to proceed.

The circuit is completed in the following manner :—A wire D from the zinc plate connects with a spring lever E, which is carried by a post F, and bears upon the periphery of a wheel G, so constructed as by its rotation to break and restore the circuit in quick succession. This wheel is attached to a cylinder H, provided with a helical line of pins projecting radially from its periphery, and in front of the barrel lies a series of spring levers I, which, when moved into position, will come in contact with the pins as the barrel or cylinder H revolves. These spring levers are carried by a metal frame K, which is connected with the earth by a ground wire K*, an arrangement of levers actuated by a stop L, is provided for each of the spring levers I, their object being to bring the levers I severally, as required, opposite a pin on the barrel, and thus to complete the electric circuit. Referring now again to the station which is to receive the message, and where the electro-magnet is situate, it must be explained how this temporary magnet is employed in effecting the transmission and the printing of the message. M is a permanent magnet, supported by a hinge joint, and having a strong attraction for the soft iron wire of the electro-magnet A, which attraction is, however, suspended on a current of electricity being passed through the coils of the electro-magnet ; a slight spring will then suffice to raise the permanent magnet out of contact with the soft iron. This movement by rocking a lever M* connected to the magnet will set free the detent N of a clock escapement, and allow a crank to rotate and lift a lever O, that carries a platen and thereby press the platen against a rotating type wheel P, the letters or signs on the periphery of which correspond to the pins on the barrel H, and come into a position to print simultaneously with the corresponding pins coming into contact with their respective spring levers I. It will thus be understood that on the depression of a stop L, say that stop which corresponds to the letter A on the type wheel, the circuit will be completed when that pin on the barrel which corresponds to the letter A comes round and touches the spring lever I, which is placed for the purpose. A current of electricity will then pass to the coils of the electro-magnet, the attraction will cease, and the permanent magnet will rise and release the de-

tent. The clock-work will then cause the platen to rise and effect the impress of the letter A on a band of paper, which travels forward between the type wheel and the platen; but inasmuch as the rotation of the barrel H is continuous, the contact of the pin and the lever will be but momentary; the current will therefore be quickly broken, and the permanent magnet will return to its depressed position, the depression of another stop will again send a current of electricity through the coils of the magnet, and the printing action will be repeated, the paper being pressed by the platen against that letter on the type wheel which corresponds to the depressed stop.

Having thus explained the principle of action of the improved apparatus, I will proceed to describe the mechanism in detail.

In sheets I., II. and III. A is an electro-magnet, above which is mounted a permanent horseshoe magnet B, carried by a cross bar b, which rocks on the centre pins b^1 b^1, projecting from pillars or supports b^2. Pendant from this cross bar b is an arm b^3, to which one end of a coiled spring b^4 is attached, the other end being connected by a cord to a hold-fast or tightening screw b^5 in the table of the instrument. On the transmission of a current of electricity through the coils of the electro-magnet, the powerful magnetic attraction which naturally exists between the permanent magnet and the soft iron of the electro-magnet will be suddenly suspended, and the coiled spring b^4 will draw up the horseshoe magnet B to the dotted position of Fig. 3, sheet III. A screw c, attached to one end of a rocking lever C, whose fulcrum pin is carried by the pillars c^1, bears upon the magnet B, it being held in contact therewith by the downward tendency imparted to it by the coiled spring c^2. The opposite end of the lever C to that which carries the bearing screw c forms a stop to the detent lever d of the crank shaft D. From the crank of this shaft a rod d^1 is pendant, and from the rod d^2 hangs a chain d^2, which supports one end of a rock lever d^3, whose fulcrum pin is carried by the pillars c^1. The opposite end of the rock lever d^3 is connected to a draw rod d^4, pendant from the cross bar of the permanent magnet B, and intended to draw down the magnet (when elevated) into contact with the electro-magnet. The spring c^2 connects the two levers C and d^3 together. To a bracket bearing from the main framing of the instrument one end of a bar

2906

e is jointed, and the other end is jointed to the pendant rod d^1; to this bar a platen E is attached by means of a binding screw, which renders it capable of adjustment to suit the type wheel F, which is mounted just above it, and in its revolution brings the several letters of the alphabet or other arbitrary symbols immediately above the platen. A strip or band of paper g (kept at tension by any suitable contrivance) passes from the paper roller G, between the platen and the type wheel, and thence out of the instrument, it being drawn forward by the bite of the rotating wheel g^2 against the cushion roller g^3. It will now be understood that if a tendency is given to the crank shaft D to rotate, by reason of its connection with a clock movement, as will be presently explained, the detent lever d will, immediately it is released from the lever C, fly round in the direction of the arrow, Fig. 1, and raise the pendant rod d^1. This movement of the rod d^1 will draw up the lever e, and, forcing the platen against the type wheel, will produce an imprint upon the paper band of the lowest letter on that wheel, the rise of the lever e being assisted by the upward pressure of the spring e^1, which is affixed to the framing of the instrument, and bears against the under side of the bar e. Immediately following upon this sudden movement of the detent arm d, will be the rocking of the lever d^3, and the depression of the magnet B (by the downward tendency of the draw rod d^4) into contact with the electro-magnet A, in which position it will be held firmly until a current of electricity is again passed through the coils of the electro-magnet; a repetition of the above described movements will then take place.

For the purpose of transmitting messeges to and fro between two given places, it will be understood that two instruments will be required (one at each station), which instruments must be so constructed and arranged as to work in harmony, and permit of currents of electricity passing to and fro in opposite directions in following seconds of time, or, in other words, of two messages being sent from opposite ends of the same lin ewire by the alternate action of the two instruments.

I will now describe in detail the mechanism employed for establishing and breaking the circuit in a manner that will produce the imprint of any given letter, as already explained, on a traveling band of paper. H is a metal barrel or cylinder, provided with radial pins h, which are set helically around it, and

are equal in number to the number of signs intended to be indicated. A continuous rotary motion is imparted to the barrel H, by means of clock-work, to be hereinafter described, and thus the pins h will be each in their turn brought into a line with a set of spring levers h^1, which are jointed to a metal frame J, that is connected with the earth plate wire. The barrel H, carries at one end a notched wheel or circuit breaker I, on which a spring lever K presses, and this lever is in metallic connection with the main conducting wire of the telegraph. Insulated from the barrel H, but revolving with it, is a second notched wheel or circuit breaker I*, which comes in contact with the spring lever as the wheel I passes out of contact, and thus a circuit (for currents running in opposite directions alternately) is continually broken and renewed. The ends of the spring levers h^1 nearest the barrel rest upon a notched bar h^2, shown detached at Fig. 6, sheet III., and standing up between them are levers h^3 (Fig. 5), which are caused to rock on their fulcra by means of draw rods h^4. These draw rods are actuated by the bell-crank levers h^5, which carry their respective stops h^6, answering respectively to some letter of the alphabet or other arbitrary sign. By depressing a stop h^6 the lever h^3, corresponding thereto, will push forward the spring lever h^1, contiguous to it, and it will then fall from the shoulder on which it rested to a lower part of the notch, and lie in a line with a pin on the barrel. As this pin comes round, it will touch a spring lever h^1, and the circuit will be complete. At this instant a letter or sign on the type-wheel F, at the signal receiving station, will have been presented to the paper band, and a current of electricity having now entered the coils of the electromagnet A at that station, the attraction between the two magnets will for the moment cease. The detent arm d will therefore be released, and the crank shaft D will cause the platen E to rise and effect the imprint desired upon the paper. The continuous rotation of the barrel H will now cause the pin h, in contact with the spring lever h^1, to raise that lever out of the lower part of the notch of the plate h^2, and the lever will then by its own elasticity spring forward and rest upon the shoulder from which it was pushed by the lever h^3. The circuit will then be broken, and the detent arm of the instrument at the other end of the wire will be again held fast, by reason

2768

of the attraction being again established between the permanent and temporary magnets.

It now remains to be explained how a return message can be transmitted between the intervals that must necessarily elapse between the following signals of the same operator. By reference to the diagram, Fig. 8, sheet IV., the arrangment of the wires for connecting the operations of the two instruments will be clearly seen, one instrument being supposed to be situate at London and the other at Birmingham. A A are the electro-magnets, connected permanently by a wire 1 with their respective circuit breakers I*, and with the earth by a wire 2. The suspended line wire 3 is connected at either end with the spring levers K K, and the metal frames which carry the spring levers h^1, that bear against the radial pins h of their respective barrels H, are connected with the earth by the wires 4 4. In order, therefore, to send a message from Birmingham to London while the attendant is operating at London, as above described, the attendant of the Birmingham instrument has merely to depress a stop, and the current will pass along the line wire 3 to London, enter the instrument at the lever K, pass thence to the wheel 1* (the lever K being at that moment in metallic contact with that wheel), and so to the electro-magnet A. The attraction will then cease between the electro-magnet and the permanent magnet of the instrument, and the printing action will then take place. In order to ink the printing surface of the type-wheel F, it is caused to revolve in contact with a flanged inking roller f, which is borne up against it by a spring f^1. Before transmitting a message to a distant station, it will be necessary to exclude all the other instruments which are in connection with the line wire from receiving and recording the message. For this purpose the following contrivance is provided in each instrument: L is a sliding bolt, capable of being moved towards the flange of a cog-wheel, M, by means of a cam d^5, attached to the crank shaft D. This wheel M is mounted on the axle of the type-wheel and revolves with it. The flange of the cog-wheel M has a slot opposite the blank on the type-wheel F, and also another slot opposite any given letter which designates the station to which the instrument belongs. Thus, for example, the letter A may represent London, the letter B Birmingham, and the letter C Coventry. The first action of the electro current is to start all the instruments on

2709

the route, and at the same time to move the bolt L nearer to the flange of the wheel M. The next movement of the crank shaft D will send the bolt L against the flange M; or, if a slot be opposite the bolt, the latter will pass through, and, being in form properly adapted to the flange, will permit the instrument to run; but if no slot is opposite the bolt the same is forced against the flange, and the revolution of the wheel is stopped by friction of contact. Suppose, then, it is desired to communicate from London to Birmingham, to the exclusion of Coventry: both instruments being ready to receive, the first closing and breaking of the circuits starts all the instruments at the same time, and by the first revolution of the crank shaft the bolt in each approaches to the flange. The next breaking and closing of the circuit, if effected while the slot in the Birmingham instrument is opposite the bolt, forces the bolt through the slot, does not suspend the operation of the instrument B, but no slot being opposite B in the instrument at Coventry, the corresponding bolt there is forced against the flange, and instantly suspends the movement of the wheel. The clock-work mechanism for driving the crank shaft and the barrel and type-wheel consists of two distinct trains, which are operated by weighted cords 1, 1* (see the detached sectional view, Fig. 4, sheet III) wound around their respective barrels, 2, 2*. On the axle of the barrel 2 is a cog wheel 3, which gears into and drives a pinion 4 on an arbor 5, which carries also a wheel 6. This wheel 6 gears with a pinion 7 on an arbor 8, which also carries a cog wheel 9, that gears into a pinion 10 on the crank shaft D, and thereby drives that shaft as soon as its detent arm *d* is released from the tail of the lever C, as already explained. A cog wheel 1 1 on the arbor 5 gears a pinion on the hub of the wheel g^2, and thereby gives to that wheel an intermittent motion, which is communicated to the band of paper that is to receive the printed message. The movement of the train of wheels which drives the barrel H and type wheel F is regulated by an escapement which, while it permits of the continued rotation of the wheels, will prevent the weighted cord 1* on the barrel 2* from running down suddenly. On the axle of this drum is a cog wheel 3* which gears into a pinion 4* on the arbor of which is a wheel 5*. This wheel 5* gears into a pinion, mounted on an arbor which

2710

carries a cog-wheel 7* in gear with a pinion on the arbor 8* of the type wheel. An escape wheel 9* is keyed to this arbor, and into the teeth of the wheel the pallets of the pallet lever 10* take. The pallet lever works on a fulcrum pin 11*, and attached to its outer end is a rod, which connects it with a vibrating string 12* secured at one extremity to the framing of the instrument. The impulse communicated to the pallet lever by the escape wheel is communicated by the rod 11* to the spring 12*, which, being thereby set in vibration, will act like the pendulum of a clock, and effect alternately the release and re-engagement of the escape wheel. A shifting bar 13* is provided for determining the extent of vibration of the spring 12*. This arrangement of vibrating spring I propose to apply in lieu of a pendulum to clock work generally, and other mechanism, the speed of which requires regulating. The rotary motion given to the type wheel F by this arrangement of mechanism is imparted to the barrel or cylinder H by means of a cog wheel 14* on the barrel shaft gearing into the flanged wheel M, which has the same number of teeth as the wheel 14*. It will thus be understood how the pins on the barrel (which pins severally answer to a letter or other symbol on the type wheel) come severally into a line with the spring levers *h* for the purpose completing the circuit at the moment that their corresponding letters on the type wheel arrive at the required position for printing.

Having now explained the nature of the invention and the manner of carrying the same into effect, I wish it to be understood that—

First, I claim the employment of the retaining or holding power of the natural magnet for arresting the action of the instrument, whether the same be applied in the manner herein described, or in any similar manner producing like results.

Second, I claim combining with the permanent magnet an adjustable spring almost sufficient to sever it from its connection with the soft iron of the electro-magnet, and a lever, or its equivalent, for restoring the permanent magnet to its contact position after being separated from the soft iron of the electro-magnet, as explained.

Third, I claim the employment of two cog wheels or circuit breakers in the same instrument so arranged that one shall be

in connection with the electro-magnet and the other with the transmitting cylinder or barrel H, and also the combined use of instruments connected as above explained, the same being so arranged that the connection will alternate at each station for every letter between the electro-magnet and the transmitting cylinder of the same instrument in such manner that the through connection is always simultaneously through the transmitting cylinder of one station and the electro-magnet of the other station, whereby the instrument at each station can at the same time be transmitting a message and receiving a message; it being understood, however, that I do not claim in general the use of a single wire for the simultaneous transmission of different messages by means of rapid changes of connection, which is not new, but only the peculiar manner as above claimed, in which I have applied it in connection with my machine.

Fourth, so arranging a bolt, and operating the same by a cam or its equivalent, that it shall act like a break upon the wheel attached to the shaft of the type wheel, and so preclude the intelligence from the station or stations on the circuit from which it is desired to withhold the communication.

Fifth, I claim the employment of a vibrating spring properly weighted at its extremity, if necessary, for governing or regulating the movement of the type wheel, and this I claim for governing the speed of other machinery without limiting its use to its connection with electro-magnetism.

Sixth, I claim printing messages by the aid of electro-magnetism from a continuously moving type wheel, printing while in motion.

Seventh, I claim the arrangement of a cylinder with pins arranged helically thereon to operate by contact with metallic points in order to close and break the circuit when this is combined, for the purposes herein set forth, with the system of stops and levers so arranged that any desired point may be thrown within the range of revolution of its corresponding pin, where it will be retained until it is struck by the said pin.

In witness whereof, I, the said Joseph Camp Griffith Kennedy, have hereunto set my hand and seal, the seventh day of January, in the year of our Lord one thousand eight hundred and fifty-six.

JOS. C. G. KENNEDY. [L. S.]

2716

(No. 80.) Defendants' Exhibit, Translation Reis Article.

J. A. W., Sp. Exr.

[For Tafels I., II. and III., see Defendants' Exhibit 5, page 24.]

[Introduced by defendants in Case, p. 420, as taken from printed record, American Bell Telephone Company vs. Albert Spencer *et al.*, pp. 182–189.]

The plates accompanying this Exhibit are the same as those accompanying Exhibit No. 5, *ante*, and the three sheets previously introduced, denominated Tafel I, Tafel II, and Tafel III. The title and contents of this Exhibit are as follows:]

YEARLY REPORT OF THE PHYSICAL SOCIETY AT FRANKFORT-A-M., 1860–1, p. 57, "On telephony by means of the galvanic current, by Philip Reis."

The extraordinary results in the field of telegraphy have probably often raised the question, if it might not be possible to transmit speech itself to a distance? Experiments made in this direction could not, however, produce any result at all satisfactory, because the vibrations of conducting media soon lose their intensities to such an extent that they are no longer appreciable by our senses.

A reproduction of sounds at certain distances by means of a galvanic current has probably been thought of, but the practical solution of this problem has certainly seemed the most doubtful to the very persons who, from their knowledge and appliances, were in the best condition to attack it. To a person having only a superficial knowledge of physic; the problem presents far less difficulties simply because the most of them are unperceived. About nine years ago I also (having an extraordinary enthusiasm for what was new, and an insufficient knowledge of physics) had the boldness to attempt the solution, but was soon forced to desist because the very first experiment convinced me of the impossibility of its solution.

Later, after further study and experience, I came to see that my first experiment had been a very rough and by no means conclusive

one; I did not, however, follow up this subject seriously, because I did not feel myself equal to the difficulties in the way.

Youthful impressions, however, are strong, and therefore not easily effaced. I could never get rid of the thought of that first experiment and its occasion, notwithstanding all that reason says to the contrary, and thus half unwillingly this project of my youth was reviewed in hours of leisure; the difficulties and the means for overcoming them were weighed; but for the present, at least, no experiment was made.

How, indeed, could a single instrument reproduce the combined effect of all the organs occupied in human speech? This was always the cardinal question; finally I got the notion of putting the question in another way—

How does *our ear* appreciate the totality of vibration produced by the organs of speech all simultaneously active? Or more generally—

How do we appreciate the vibrations of several simultaneously sounding bodies?

To answer this question, we must, in the first place, understand what must happen in order that we may perceive a single tone.

Without an ear any tone is nothing else than a recurrent condensation and rarefaction of some body repeated at least seven or eight times in a second. If this occurs in the same medium in which we are, the membrane of the ear is at each condensation forced towards the middle ear, to be moved at the subsequent rarefaction in the opposite direction. These vibrations produce a synchronous raising and falling of the hammer upon the anvil (according to other authorities, an approach or receding of the ear-bone particles), and a similar number of tremors in the fluid of the cochlea, in which the filaments of the auditory nerve are distributed. The greater the condensation of the conducting medium at any given moment, the greater is the amplitude of vibration of the membrane and hammer, and consequently the more powerful the blow upon the anvil and the vibration of the nerves by means of the fluid.

The office of our organs of hearing is, therefore, to transmit with certainty up to the auditory nerve every condensation and rarefaction occurring in the surrounding medium. But the office of the auditory nerve is to bring to our consciousness the vibrations of matter which have occurred in a given time, both as regards number and amplitude. Here, for the first time, certain combinations receive a name; here, certain vibrations are sounds or noises.

What our auditory nerve perceives is, then, simply the action of a force coming within the range of consciousness, and this force can be represented both as to duration and magnitude by a curve, graphically.

Let *a b* represent any given time, and the curve above the line condensation (+), the curve below the line rarefaction (—), then any ordinate raised from the end of any abscissa will represent the degree of condensation, at the time represented by its base, in consequence of which the drum of the ear vibrates.

Our ear can, under no circumstances, appreciate more than can be represented by these curves, and this indeed is entirely sufficient to give us a clear perception of any sound or any combination of sounds.

If several sounds are produced at the same time, the conducting medium is subjected to the influence of several simultaneous forces, and the two following laws will hold good: If the forces act in the same direction, the amplitude is proportional to the sum of the forces; if the forces act in opposite directions, the amplitudes are proportional to the differences of the opposing forces.

If, for example, in the case of three sounds, we draw the curve of condensation of each separately by a summation of the ordinates of corresponding abscissas, we can determine new ordinates and develop a new curve, which might be called the combination curve. This represents exactly what our ear perceives of the three simultaneous sounds. The fact that the musician can distinguish the three sounds need not surprise us any more than the fact that any one acquainted with the theory of colors can in green discover blue and yellow; but the combination curves in plate I. show that this difficulty is a slight one, for in these curves all the relations of the components successively recur. In the case of chords of more than three notes the relations are not so readily seen from the drawing Plate II. for example. In the case of such chords, however, the skilled musician also finds difficulty in recognizing the separate notes.

Plate III. illustrates discord. Why discords impress us un-

pleasantly I will leave my readers to judge at this time, though I may perhaps return to the subject subsequently in another paper.

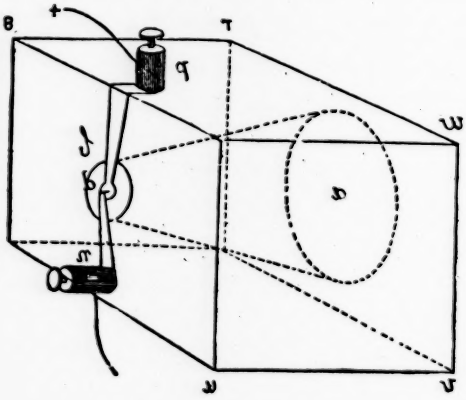
From the proceeding it follows:

FIRST. Every sound and every combination of sounds, on striking our ear, causes vibration of the drum of the ear that may be represented by a curve.

SECOND. The course of these vibrations simply gives us a conception (appreciation) of the sound, and every alteration changes the conception (appreciation).

As soon, then, as it is possible to produce, anywhere and in any manner, vibrations whose curves shall be the same as those of any sounds or combination of sounds, we shall receive the same impression as that sound or combination of sounds would have produced.

With the above principles as a foundation, I have succeeded in constructing an apparatus with which I am enabled to reproduce the sounds of various instruments, and even to a certain extent the human voice. It is very simple, and by means of the figure will be easily understood from the following explanation.



In the cubical block of wood *r*, *s*, *t*, *u*, *v*, *w*, *x*, there is a conical perforation *a*, closed at one end by a membrane *b* (pig's intestine), upon the middle of which there is cemented a conducting strip of platinum, this is connected with the binding screw *p*. From the binding screw *n* another thin strip of metal extends until over the middle of the membrane, and ends here in a platinum wire placed at right angles to its length and surface.

From the binding screw *p*, a conducting wire runs through the battery to the distant station, being connected with a coil of silk-covered copper wire, and this again is connected with a conductor leading back to the binding screw *n*.

The coil at the distant station is about six inches long, is composed of six layers of fine wire, and, as a core in its centre, has a knitting-needle which projects about two inches at both ends. By means of the projecting ends, the coil rests upon two bridges of a resonant case. (All this part can of course be replaced by any other apparatus by means of which the well-known "galvanic sound" can be produced.)

If, now, sounds or sound combinations are produced in the neighborhood of the block, so that sufficiently powerful waves reach the opening *a*, then these sounds cause the membrane *b*, to vibrate. At the first condensation the hammer-like wire *d* is pushed back, at the rarefaction it can follow the retreating membrane, and the current traversing the strip is broken, until the membrane forced by a new condensation again presses the strip (proceeding from *p*) against *d*. In this way each sound wave causes a breaking and closing of the circuit.

At each closing of the circuit the atoms of the iron wire in the distant spiral are moved away from each other (Pouillet Muller, page 304, Vol. II., Fifth Edition); on breaking the circuit these atoms seek to regain their position of equilibrium. When this happens, in consequence of the reciprocal actions of elasticity and inertia, a number of vibrations are produced, and they give the longitudinal sound of the rod (see as above). This is the case if the breakings and closings of the circuit occur with comparative slowness. If they occur more rapidly than the oscillations of the iron core, due to its elasticity, the atoms cannot complete their circuits. The paths described become shorter in proportion as the interruptions are more frequent, but then are just as numerous as these.

The iron wire no longer gives its longitudinal sound, but a sound whose pitch corresponds to the number of interruptions (in a given time); this is equivalent to saying the wire reproduces the sound conveyed to the interrupter. The intensity also of this sound is proportional to that of the original one, for in proportion as this is more intense the motions of the membrane are greater; the motions of the hammer also, and finally the time during which the circuit is broken is greater, and consequently, to a certain extent, the motions of the atoms in the reproducing wire are greater,

we perceiving them as greater vibrations, in just the same way as we would have perceived the original sound wave.

As the length of the conducting wire can undoubtedly be made as great as in direct telegraphy, I have called my instrument "telephone."

Now, in reference to the capabilities of the telephone, it may be stated that I was enabled to render audible to the members of a large assembly (the Physical Society at Frankfort-a-M.), melodies which were sung not very loud into the apparatus in another house three hundred feet away, with closed doors.

Other experiments showed that the sounding wire was capable of reproducing complete chords of three notes of a piano, upon which the telephone was placed, and that it reproduces equally well the sound of other instruments—accordion, clarinet, horn, organ, pipes, etc., provided that the sounds are within the compass F–*f*‴.

Of course, in all experiments sufficient precautions were taken to insure that there was no direct conduction of sound. This is very easily done by making a momentary short circuit immediately in front of the coil, by which means its action is temporarily interrupted.

Hitherto it has not been possible to reproduce human speech with a distinctness sufficient for every one. The consonants are for the most part reproduced pretty distinctly, but the vowels as yet not in an equal degree. The cause of this I will attempt to explain.

According to the experiments of Willis, Helmholtz and others, vowel sounds can be produced artificially, if the vibrations of one body are from time to time augmented by those of another, somewhat as follows:

An elastic wheel is set in vibration by the blow of a tooth on a toothed wheel; the first vibration is the greatest, and each subsequent one is smaller than the preceding.

If to vibrations of this kind (the spring not coming to rest in the meantime) the blow of a new tooth is added, the following vibration will be again a maximum, and so on.

The pitch of a sound produced in this way depends upon the

number of vibrations in a given time, but the character of the sound upon the number of intensifications in the same time. Two vowels having the same pitch would differ in about the way represented by the curves (Figs. 1, 2), while the same sound without any vowel character would be represented by the curve (Fig. 3).

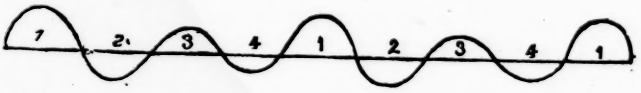
Fig. 1. 

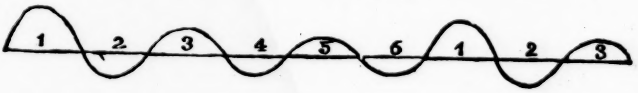
Fig. 2. 

Fig. 3.

Our organs of speech probably produce the vowels in the same manner, through the combined action of the upper and lower vocal chords, or of these latter and the cavity of the mouth.

My apparatus reproduces the number of vibrations, but with an intensity much less than that of the original ones; but still, as I have reason to believe, to a certain degree proportional among themselves. But in the case of these generally small vibrations the difference between large and small vibrations is more difficult to perceive than in the case of the original waves, and the vowel is, therefore, more or less indistinct.

Whether or not my views as to the curves corresponding to sound combinations are correct could perhaps be decided by means of the new phonautograph of Duhamel.

(" Vierordt Physiology," page 254.)

It may be that for the practical application of the telephone much remains to be done; for physics it has already sufficient interest, from the fact that it opens a new field for research.

Friedrichsdorf, near Frankfort, A. M., December, 1861.

(No. 81.) Defendants' Exhibit, The Telephone.

[Put in Evidence by Defendants.]

J. A. W., Sp. Ex'r.

[Introduced in Case, p. 420.]

A LECTURE, entitled Researches in Electric Telephony, by Professor Alexander Graham Bell, delivered before the Society of Telegraph Engineers, October 31st, 1877. Published by the Society, and edited by Lieut. Col. Frank Bolton, C.E., Hon. Secretary, and William Edward Langdon, Acting Secretary. London: E. & F. N. Spon, 46, Charing Cross. New York: 446 Broome street. 1878.

EXTRACTS OF PROCEEDINGS OF THE SOCIETY OF TELEGRAPH ENGINEERS.

Special General Meeting, held at 25, Great George street, Westminster, on Wednesday, the 31st October, 1877, Professor Abel, C.B., F.R.S., President, in the Chair.

THE PRESIDENT: Gentlemen, the Council of the Society of Telegraph Engineers felt that they were sure of doing what the members would consider right in summoning a special meeting for the twofold purpose of giving a welcome to Professor Bell to this country, and affording the members an opportunity of hearing from him an account, which he has been so good as to promise to give us, of the nature, history, and development of what may well be called one of the most interesting discoveries of our age. Our time is very precious this evening. We all desire to hear everything Professor Bell can tell us on this subject, and many gentlemen will probably desire afterwards to ask questions or discuss the subject, for I see present a great number of eminent scientific men. I will not waste another moment, but at once call upon Professor Bell to commence his discourse on the Electric Telephone.

RESEARCHES IN ELECTRIC TELEPHONY.

(By Professor Alexander Graham Bell.)

PROFESSOR BELL: Mr. President, and Gentlemen of the Society of Telegraph Engineers. It is to-night my pleasure as well as duty to

give you some account of the telephonic researches in which I have been so long engaged. Many years ago my attention was directed to the mechanism of speech by my father, Alexander Melville Bell, of Edinburgh, who has made a life-long study of the subject. Many of those present may recollect the invention by my father of a means of representing, in a wonderfully accurate manner, the positions of the vocal organs in forming sounds. Together we carried on quite a number of experiments, seeking to discover the correct mechanism of English and foreign elements of speech; and I remember especially an investigation in which we were engaged concerning the musical relations of vowel sounds. When vowel sounds are whispered each vowel seems to possess a particular pitch of its own, and by whispering certain vowels in succession a musical scale can be distinctly perceived. Our aim was to determine the natural pitch of each vowel, but unexpected difficulties made their appearance, for many of the vowels seemed to possess a double pitch; one due, probably, to the resonance of the air in the mouth, and the other to the resonance of the air contained in the cavity behind the tongue, comprehending the pharynx and larynx.

I hit upon an expedient for determining the pitch which at that time I thought to be original with myself. It consisted in vibrating a tuning-fork in front of the mouth while the positions of the vocal organs for the various vowel sounds were silently taken. It was found that each vowel position caused the reinforcement of some particular fork or forks.

I wrote an account of these researches to Mr. Alex. J. Ellis, of London, whom I have very great pleasure in seeing here to-night. In reply he informed me that the experiments related had already been performed by Helmholtz, and in a much more perfect manner than I had done. Indeed, he said that Helmholtz had not only analyzed the vowel sounds into their constituent musical elements, but had actually performed the synthesis of them.

He had succeeded in producing, artificially, certain of the vowel sounds by causing tuning-forks of different pitch to vibrate simultaneously by means of an electric current. Mr. Ellis was kind enough to grant me an interview for the purpose of explaining the apparatus employed by Helmholtz in producing these extraordinary effects, and I spent the greater part of a delightful day with him in investigating the subject. At that time, however, I was too slightly acquainted with the laws of electricity fully to understand the explanations given; but the interview had the effect of arousing

my interest in the subjects of sound and electricity, and I did not rest until I had obtained possession of a copy of Helmholtz' great work, and had attempted, in a crude and imperfect manner it is true, to reproduce his results. While reflecting upon the possibilities of the production of sound by electrical means, it struck me that the principle of vibrating a tuning-fork by the intermittent attraction of an electro-magnet might be applied to the electrical production of music.

I imagined to myself a series of tuning-forks of different pitches, arranged to vibrate automatically in the manner shown by Helmholtz, each fork interrupting at every vibration a voltaic current; and the thought occurred, "Why should not the depression of a key like that of a piano direct the interrupted current from any one of these forks, through a telegraph wire, to a series of electro-magnets operating the strings of a piano or other musical instrument, in which case a person might play the tuning-fork piano in one place and the music be audible from the electro-magnetic piano in a distant city?"

The more I reflected upon this arrangement the more feasible did it seem to me; indeed, I saw no reason why the depression of a number of keys at the tuning-fork end of the circuit should not be followed by the audible production of a full chord from the piano in the distant city, each tuning-fork affecting at the receiving end that string of the piano with which it was in unison. At this time the interest which I felt in electricity led me to study the various systems of telegraphy in use in this country and in America. I was much struck with the simplicity of the Morse alphabet, and with the fact that it could be read by sound. Instead of having dots and dashes recorded upon paper, the operators were in the habit of observing the duration of the click of the instruments, and in this way were enabled to distinguish by ear the various signals.

It struck me that in a similar manner the duration of a musical note might be made to represent the dot or dash of the telegraph code, so that a person might operate one of the keys of the tuning-fork piano referred to above, and the duration of the sound proceeding from the corresponding string of the distant piano be observed by an operator stationed there. It seemed to me that in this way a number of distinct telegraph messages might be sent simultaneously from the tuning-fork piano to the other end of the circuit, by operators each manipulating a different key of the instrument. These messages would be read by operators stationed at the

distant piano, each receiving operator listening for signals of a certain definite pitch, and ignoring all others. In this way could be accomplished the simultaneous transmission of a number of telegraphic messages along a single wire, the number being limited only by the delicacy of the listener's ear. The idea of increasing the carrying power of a telegraph wire in this way took complete possession of my mind, and it was this practical end that I had in view when I commenced my researches in Electric Telephony.

In the progress of science it is universally found that complexity leads to simplicity, and in narrating the history of scientific research it is often advisable to begin at the end.

In glancing back over my own researches, I find it necessary to designate, by distinct names, a variety of electrical currents by means of which sounds can be produced, and I shall direct your attention to several distinct species of what may be termed "telephonic" currents of electricity. In order that the peculiarities of these currents may be clearly understood, I shall ask Mr. Frost to project upon the screen a graphical illustration of the different varieties.

The graphical method of representing electrical currents here shown is the best means I have been able to devise of studying in an accurate manner the effects produced by various forms of telephonic apparatus, and it has led me to the conception of that peculiar species of telephonic current here designated as undulatory, which has rendered feasible the artificial production of articulate speech by electrical means.

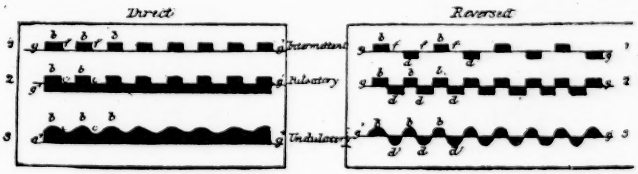


Fig. 1.

A horizontal line ($g\ g^1$) is taken as the zero of current, and impulses of positive electricity are represented above the zero line, and negative impulses below it, or *vice versa*.

The vertical thickness of any electrical impulse (b or d), measured from the zero line, indicates the intensity of the electrical

current at the point observed, and the horizontal extension of the electric line (*b* or *d*) indicates the duration of the impulse.

Nine varieties of telephonic currents may be distinguished, but it will only be necessary to show you six of these. The three primary varieties designated as "intermittent," "pulsatory," and "undulatory," are represented in lines 1, 2, and 3.

Sub-varieties of these can be distinguished as "direct" or "reversed" currents according as the electrical impulses are all of one kind or are alternately positive and negative. "Direct" currents may still further be distinguished as "positive" or "negative," according as the impulses are of one kind or of the other.

An intermittent current is characterized by the alternate presence and absence of electricity upon the circuit,

A pulsatory current results from sudden or instantaneous changes in the intensity of a continuous current; and

An undulatory current is a current of electricity, the intensity of which varies in a manner proportional to the velocity of the motion of a particle of air during the production of a sound; thus the curve representing graphically the undulatory current for a simple musical tone is the curve expressive of a simple pendulous vibration—that is, a sinusoidal curve.

Telephonic currents of electricity may be				
Intermittent.	Direct.	Positive.	1	Positive intermittent current.
		Negative.	2	Negative " "
	———	Reversed.	3	Reversed " "
Pulsatory.	Direct.	Positive.	4	Positive pulsatory current.
		Negative.	5	Negative " "
	———	Reversed.	6	Reversed " "
Undulatory.	Direct.	Positive.	7	Positive undulatory current.
		Negative.	8	Negative " "
	———	Reversed.	9	Reversed " "

And here I may remark that, although the conception of the undulatory current of electricity is entirely original with myself, methods of producing sound by means of intermittent and pulsatory currents have long been known. For instance, it was long since discovered that an electro-magnet gives forth a decided sound when it is suddenly magnetized or demagnetized. When the circuit upon which it is placed is rapidly made and broken a succession of explosive noises proceeds from the magnet. These sounds produce

upon the ear the effect of a musical note when the current is interrupted a sufficient number of times per second. The discovery of "galvanic music" by Page, in 1837, led inquirers in different parts of the world almost simultaneously to enter into the field of telephonic research; and the acoustical effects produced by magnetization were carefully studied by Marrian, Beatson, Gassiot, De La Rive, Matteucci, Guillemin, Wertheim, Wartmann, Janniar, Joule, Laborde, Legat, Reis, Poggendorff, Du Moncel, Delezenne and others. It should also be mentioned that Gore obtained loud musical notes from mercury, accompanied by singularly beautiful crispations of the surface during the course of experiments in electrolysis; Page produced musical tones from Trevelyan's bars by the action of the galvanic current; and further, it was discovered by Sullivan that a current of electricity is generated by the vibration of a wire composed partly of one metal and partly of another. The current was produced so long as the wire emitted a musical note, but stopped immediately upon the cessation of the sound.

For several years my attention was almost exclusively directed to the production of an instrument for making and breaking a voltaic circuit with extreme rapidity, to take the place of the transmitting tuning-fork used in Helmholtz's researches. I will not trouble you with the description of all the various forms of apparatus that were devised, but will merely direct your attention to one of the

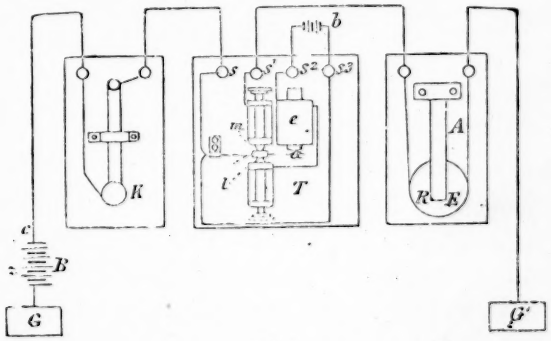


Fig. 2.

best of them, shown in figure 2. In the transmitting instrument T, a steel reed *a* is employed, which is kept in continuous vibration by the action of an electro-magnet *e* and local battery. In the course of its vibration the reed strikes alternately against two fixed points

a, V, and thus completes alternately a local and a main circuit. When the key K is depressed an intermittent current from the main battery B is directed to the line-wire W, and passes through the electro-magnet E of a receiving instrument R at the distant end of the circuit, and thence to the ground G. The steel reed A is placed in front of the receiving magnet, and when its normal rate of vibration is the same as the reed of the transmitting instrument it is thrown into powerful vibration, emitting a musical tone of a similar pitch to that produced by the reed of the transmitting instrument; but if it is normally of a different pitch it remains silent.

A glance at Figs. 3, 4 and 5 will show the arrangement of such instruments upon a telegraphic circuit, designed to enable a number of telegraphic despatches to be transmitted simultaneously along

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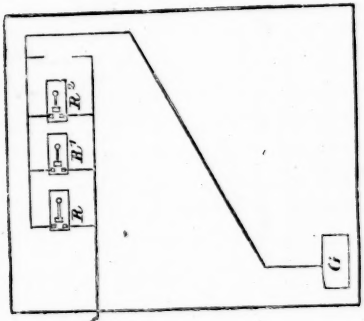

Fig. 5.

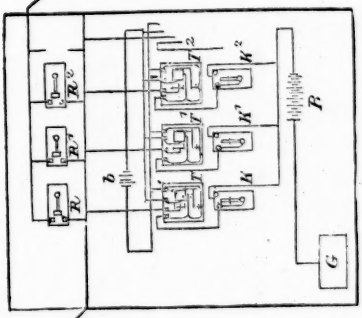

Fig. 4.

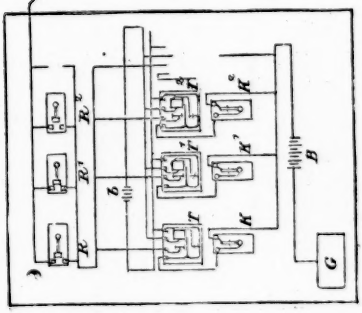

Fig. 3.

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the same wire. The transmitters and receivers that are numbered alike have the same pitch or rate of vibration. Thus the reed of T^1 is in unison with the reeds T^1 and R^1 at all the stations upon the circuit, so that a telegraphic despatch sent by the manipulation of the key K^1 at the station shown in Fig. 3 will be received upon the receiving instruments K^1 at all the other stations upon the circuit. Without going into details, I shall merely say that the great defects of this plan of multiple telegraphy were found to consist, firstly, in the fact that the receiving operators were required to possess a good musical ear in order to discriminate the signals; and secondly, that the signals could only pass in one direction along the line (so that two wires would be necessary in order to complete communication in both directions). The first objection was got over by employing the device which I term a "vibratory circuit breaker," shown in the next diagram, whereby musical signals can be automatically recorded.

Fig. 6 shows a receiving instrument R, with a vibratory circuit breaker v attached. The light spring lever v overlaps the free end of the steel reed A, and normally closes a local circuit, in which may be placed a Morse sounder or other telegraphic apparatus. When the reed A is thrown into vibration by the passage of a musical signal, the spring arm v is thrown upwards, opening the local circuit at the point 5. When the spring-arm v is so arranged

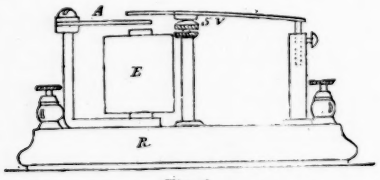

Fig. 6.

as to have normally a much slower rate of vibration than the reed A^1, the local circuit is found to remain permanently open during the vibration of A, the spring arm v coming into contact with the point 5 only upon the cessation of the receiver's vibration. Thus the signals produced by the vibration of the reed A are reproduced upon an ordinary telegraphic instrument in the local circuit.

Fig. 7 shows the application of electric telephony to autographic telegraphy.

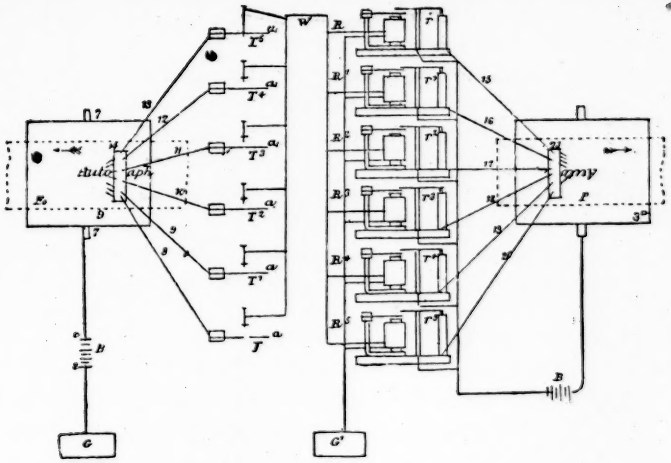

Fig. 7.

T, T¹, &c., represent the reeds of transmitting instruments of different pitch, R, R¹, &c., the receivers at the distant station of corresponding pitch, and *r*, *r*¹, &c., the vibratory circuit breakers attached to the receiving instruments, and connected with metallic bristles, 21, resting upon chemically prepapared paper P. The message or picture, to be copied, is written upon a metallic surface, F *o*, with non-metallic ink, and placed upon a metallic cylinder 7, connected with the main battery B; and the chemically prepared paper P, upon which the message is to be received, is placed upon a metallic cylinder connected with the local battery B at the receiving station. When the cylinder at either end of the circuit are rotated in the direction of the arrows—but not necessarily at the same rate of speed—a fac-simile of whatever is written or drawn upon the metallic surface F *o* appears upon the chemically prepared paper P.

The method by means of which the musical signals may be sent simultaneously in both directions along the same circuit is shown in our next illustration, figures 8, 9, and 10. The arrangement is similar to that shown in figures 3, 4 and 5, excepting that the intermittent current from the transmitting instrument is passed through the primary wires of an induction coil, and the receiving instruments are placed in circuit with the secondary wire. In this way free earth communication is secured at either end of the circuit, and

the musical signals produced by the manipulation of any key are received at all the stations upon the line. The great objection to this plan is the extreme complication of the parts and the necessity of employing local and main batteries at every station. It was also found by practical experiment that it was difficult, if not impossible, upon either of the plans here shown, to transmit simultaneously the number of musical tones that theory showed to be feasible. Mature consideration revealed the fact that this difficulty lay in the nature of the electrical current employed, and was finally obviated by the invention of the undulatory current.

It is a strange fact that important inventions are often made almost simultaneously by different persons in different parts of the world, and the idea of multiple telegraphy as developed in the preceding diagrams seems to have occurred independently to no less than four other inventors in America and Europe. Even the details of the arrangement upon circuit—shown in figures 3, 4, 5, and 8, 9, 10—are extremely similar in the plans proposed by Mr. Cromwell Varley of London, Mr. Elisha Gray of Chicago, Mr. Paul La Cour of Copenhagen, and Mr. Thomas Edison of Newark, New Jersey. Into the question of priority of invention, of course, it is not my intention to go to-night.

That the difficulty in the use of an intermittent current may be more clearly understood, I shall ask you to accompany me in my explanation of the effect produced when two musical signals of different pitch are simultaneously directed along the same circuit. Fig. 11 shows an arrangement whereby the reeds a a^1 of two transmitting instruments are caused to interrupt the current from the same battery B. We shall suppose the musical interval between the two reeds to be a major third, in which case their vibrations are in

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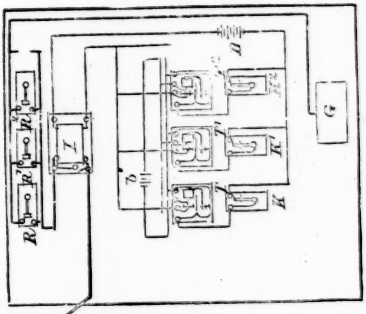

Fig. 10.

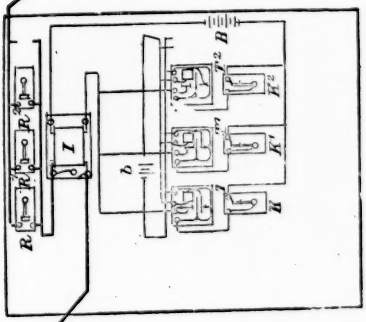

Fig. 9.

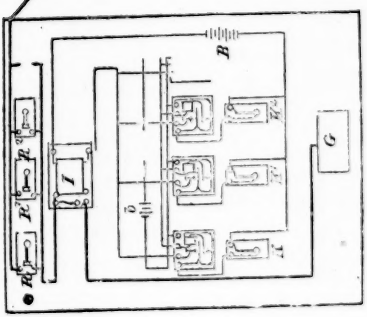

Fig. 8.

the ratio of 4 to 5, *i. e.*, 4 vibrations of a are made in the same time as 5 vibrations of a^1. A^2 and B^2 represent the intermittent currents

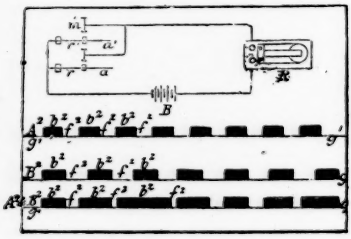

Fig. 11.

produced, 4 impulses of B^2 being made in the same time as 5 impulses of A^2. The line $A^2 + B^2$ represents the resultant effect upon the main line when the reeds a and a^1 are simultaneously caused to make and break the same circuit, and from the illustration you will perceive that the resultant current, whilst retaining a uniform intensity, is less interrupted when both reeds are in operation than when one alone is employed. By carrying your thoughts still further you will understand that when a large number of reeds of different pitch or of different rates of vibration are simultaneously making and breaking the same circuit the resultant effect upon the main line is practically equivalent to one continuous current.

It will also be understood that the maximum number of musical signals that can be simultaneously directed along a single wire without conflict depends very much upon the ratio which the "make" bears to the "break," the shorter the contact made, and the longer the break, the greater the number of signals that can be transmitted without confusion, and *vice versa*. The apparatus by means of which this theoretical conclusion has been verified is here to-night, and consists of an ordinary parlour harmonium, the reeds of which are operated by wind in the usual manner. In front of each reed is arranged a metal screw, against which the reed strikes in the course of its vibration. By adjusting the screw the duration of the contact can be made long or short. The reeds are connected with one pole of a battery, and the screws against which they strike communicate with the line-wire, so that intermittent impulses from the battery are transmitted along the line-wire during the vibration of the reeds.

We now proceed to the next illustration. Without entering into

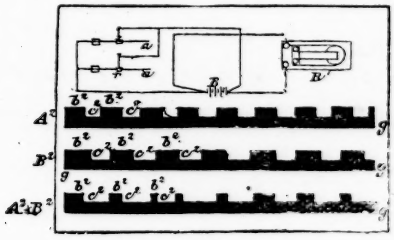

Fig. 12.

the details of the calculation you will see that with a pulsatory current the effect of transmitting musical signals simultaneously is nearly equivalent to a continuous current of minimum intensity—see A^2+B^2, Fig. 12; but when undulatory currents are employed the effect is different—see Fig. 13. The current from the battery B is

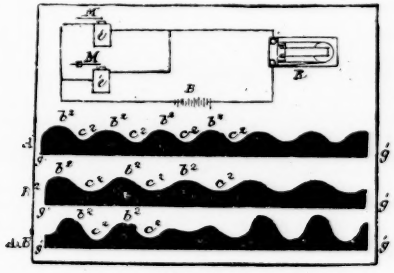

Fig. 13.

thrown into waves by the inductive action of iron or steel reeds M, M^1, vibrated in front of electro-magnets e e^1, placed in circuit with the battery; A^2 and B^2 represent the undulations caused in the current by the vibration of the magnetized bodies, and it will be seen that there are four undulations of B^2 in the same time as five undulations of A^2. The resultant effect upon the main line is expressed by the curve A^2+B^2, which is the algebraical sum of the sinusoidal curves A^2 and B^2. A similar effect is produced when reversed undulatory currents are employed as shown in Fig. 14, where the current is produced by the vibration of permanent magnets M M^1 in front of electro-magnets (e e^1), united upon a circuit without a voltiac battery. It will be understood from Figs. 13 and

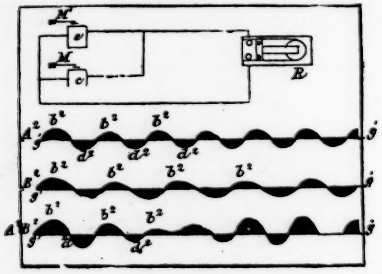

Fig. 14.

14 that the effect of transmitting musical signals of different pitches simultaneously along a single wire is not to obliterate the vibratory character of the current as in the case of intermittent and pulsatory currents, but to change the shapes of the electrical undulations. In fact, the effect produced upon the current is precisely analogous to the effect produced in the air by the vibration of the inducing bodies M M¹. Hence it should be possible to transmit as many musical tones simultaneously through a telegraph wire as through the air. The possibility of using undulatory currents for the purposes of multiple telegraphy enabled me to dispense entirely with the complicated arrangements of the circuit shown in Figs. 3, 4, 5 and 8, 9, 10, and to employ a single battery for the whole circuit, retaining only the receiving instruments formerly shown. This arrangement is represented in Figs. 15, 16 and 17. Upon vibrating the steel reed of a receiver R, R¹, at any station, by any mechanical means, the corresponding reeds at all the other stations are thrown into vibra-

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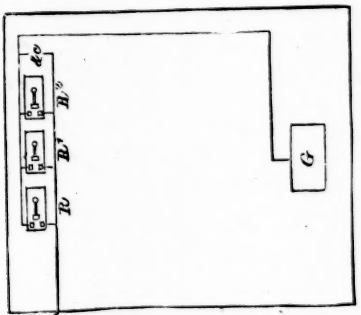


Fig. 17.

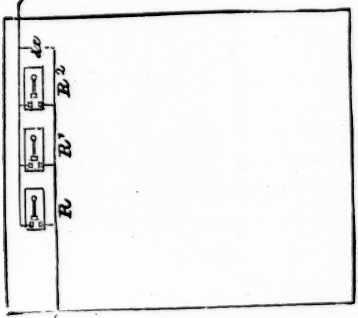


Fig. 16.

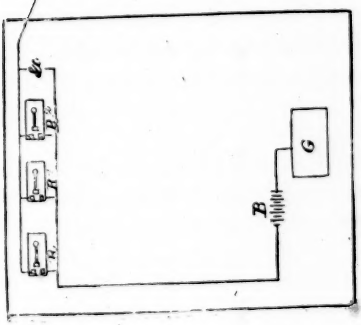


Fig. 15.

tion, reproducing the signal. By attaching the steel reeds to the poles of a powerful permanent magnet, as shown in Fig. 19, the signals can be produced without the aid of a battery.

I have formerly stated that Helmholtz was enabled to produce vowel soonds artificially by combining musical tones of different pitches and intensities. His apparatus is shown in Fig. 18. Tuning-

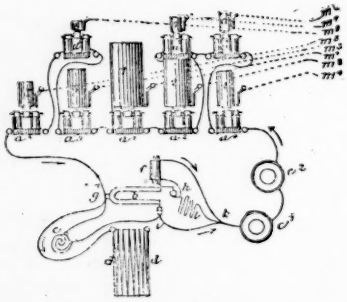


Fig. 18.*

forks of different pitch are placed between the poles of electro-magnets (a^1, a^2, &c.) and are kept in continuous vibration by the action of an intermittent current from the fork *b*. Resonators 1, 2, 3, &c., are arranged so as to reinforce the sounds, in a greater or less degree, according as the exterior orifices are enlarged or contracted.

Thus it will be seen that upon Helmholtz's plan the tuning-forks themselves produce tones of uniform intensity, the loudness being varied by an external reinforcement; but it struck me that the same results would be obtained, and in a much more perfect manner, by causing the tuning-forks themselves to vibrate with different degrees of amplitude. I therefore devised the apparatus shown in Fig. 19, which was my first form of articulating telephone. In this figure a harp of steel rods is employed attached to the poles of a a permanent magnet N. S. When any one of the rods is thrown into vibration an undulatory current is produced in the coils of the electro-magnet E and the electro-magnet E^1 attracts the rods of the harp H^1 with a varying force, throwing into vibration that rod which is in unison with that vibrated at the other end of the circuit.

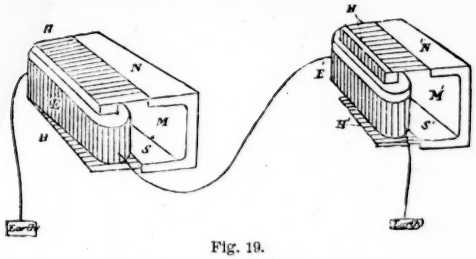


Fig. 19.

Not only so, but the amplitude of vibration in the one will determine the amplitude of vibration in the other, for the intensity of the induced current is determined by the amplitude of the inducing vibration, and the amplitude of the vibration at the receiving end depends upon the intensity of the attractive impulses. When we sing into a piano, certain of the strings of the instrument are set in vibration sympathetically by the action of the voice with different degrees of amplitude, and a sound, which is an approximation to the vowel uttered, is produced from the piano. Theory shows that had the piano a very much larger number of strings to the octave, the vowel sounds would be pecfectly reproduced. My idea of the action of the apparatus shown in fig. 19 was this: Utter a sound in the neighborhood of the harp H and certain of the rods would be thrown into vibration with different amplitudes. At the other end of the circuit the corresponding rods of the harp H^1 would vibrate with their proper relations of force, and the timbre of the sound would be reproduced. The expense of constructing such an apparatus as that shown in Fig. 19 deterred me from making the attempt, and I sought to simplify the apparatus before venturing to have it made.

I have before alluded to the invention by my father of a system of physiological symbols for representing the action of the vocal organs, and I have been invited by the Boston Board of Education to conduct a series of experiments with the system in the Boston school for the deaf and dumb. It is well known that deaf mutes are dumb merely because they are deaf, and that there is no defect in their vocal organs to incapacitate them from utterance. Hence it was thought that my father's system of pictorial symbols, popularly known as visible speech, might prove a means whereby we could teach the deaf and dumb to use their vocal organs and to

2741

speak. The great success of these experiments urged upon me the advisability of devising methods of exhibiting the vibrations of sound optically, for use in teaching the deaf and dumb. For some time I carried on experiments with the manometric capsule of Koenig, and with the phonautograph of Leon Scott. The scientific apparatus in the Institute of Technology in Boston was freely placed at my disposal for these experiments, and it hapened that at that time a student of the Institute of Technology, Mr. Maurey, had invented an improvement upon the phonautograph. He had succeeded in vibrating by the voice a stylus of wood about a foot in length, which was attached to the membrane of the phonautograph, and in this way he had been enabled to obtain enlarged tracings upon a plane surface of smoked glass. With this apparatus I succeeded in producing very beautiful tracings of the vibrations of the air for vowel sounds. Some of these tracings are shown in Fig. 20. I was much struck with this improved form of apparatus, and it

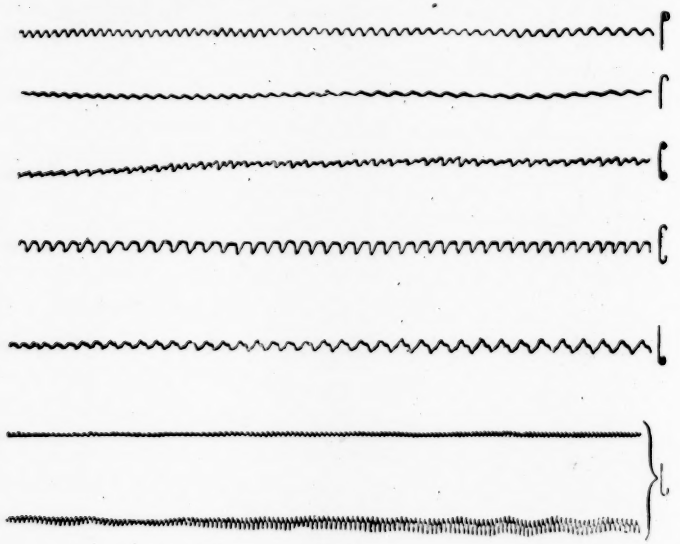


Fig. 20.

occurred to me that there was a remarkable likeness between the manner in which this piece of wood was vibrated by the membrane of the phonautngraph and the manner in which the ossiculæ of the human ear was moved by the tympanic membrane. I determined

therefore to construct a phonautograph modeled still more closely upon the mechanism of the human ear, and for this purpose I sought the assistance of a distinguished aurist in Boston, Dr. Clarence J. Blake. He suggested the use of the human ear itself as a phonautograph, instead of making an artificial imitation of it. The idea was novel and struck me accordingly, and I requested my friend to prepare a specimen for me, which he did. The apparatus, as finally constructed, is shown in Fig. 21. The stapes was removed and a

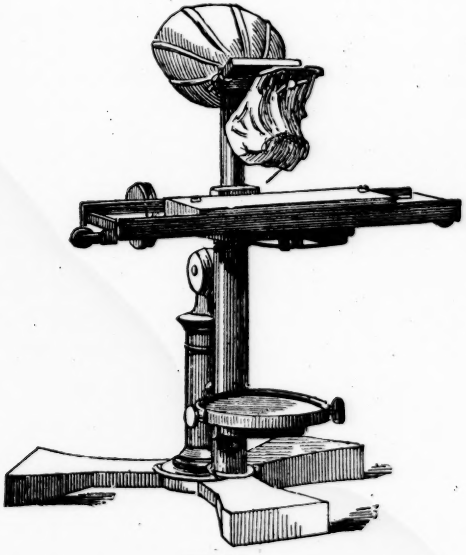


Fig. 21.

stylus of hay about an inch in length was attached to the end of the incus. Upon moistening the membrana-tympani and the ossiculæ with a mixture of glycerine and water, the necessary mobility of the parts was obtained; and upon singing into the external artificial ear the stylus of hay was thrown into vibration, and tracings were obtained upon a plane surface of smoked glass passed rapidly underneath. While engaged in these experiments I was struck with the remarkable disproportion in weight between the membrane and the bones that were vibrated by it. It occurred to me that if a membrane as thin as tissue paper could control the vibration of bones that were, compared to it, of immense size and

weight, why should not a larger and thicker membrane be able to vibrate a piece of iron in front of an electro-magnet, in which case the complication of steel rods shown in my first form of telephone, Fig. 19, could be done away with, and a simple piece of iron attached to a membrane be placed at either end of the telegraphic circuit.

Fig. 22 shows the form of apparatus that I was then employing for producing undulatory currents of electricity for the purposes of multiple telegraphy. A steel reed A was clamped firmly by one extremity to the uncovered leg *h* of an electro-magnet E, and the free end of the reed projected above the covered leg. When the reed A was vibrated in any mechanical way, the battery current was thrown into waves, and electrical undulations traversed the circuit B, E, W, E^1, throwing into vibration the corresponding reed A^1 at the other end of the circuit. I immediately proceeded to put my new idea to the

Fig. 22.

test of practical experiment, and for this purpose I attached the reed A (Fig. 23), loosely by one extremity to the uncovered pole *h* of the magnet, and fastened the other extremity to the centre of a stretched

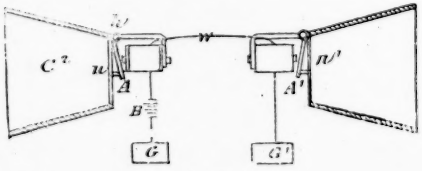


Fig. 23.

membrane of goldbeaters' skin *n*. I presumed that upon speaking in the neighborhood of the membrane *n* it would be thrown into vibration and cause the steel reed A to move in a similar manner, occasioning undulations in the electrical current that would correspond to the changes in the density of the air during the production of the sound; and I further thought that the change of the intensity of the current at the receiving end would cause the magnet there to attract

the reed A^1 in such a manner that it should copy the motion of the reed A, in which case its movements would occasion a sound from the membrane n^1 similar in timbre to that which had occasoned the original vibration.

The results, however, were unsatisfactary and discouragaing. My friend Mr. Thomas A. Watson, who assisted me in this first experiment, declared that he heard a faint sound proceed from the telephone at his end of the circuit, but I was unable to verify his assertion. After many experiments attended by the same only partially successful results, I determined to reduce the size and weight of the spring as much as possible. For this purpose I glued a piece of clock spring about the size and shape of my thumb nail, firmly to the centre of the diaphragm, and had a similar instrument at the other end (Fig. 24); we were then enabled to obtain distinctly audible effects. I remember an experiment made with this telephone,

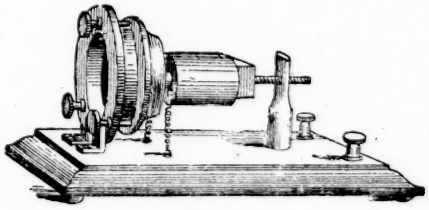


Fig. 24.

which at the time gave me great satisfaction and delight. One of the telephones was placed in my lecture-room in the Boston University, and the other in the basement of the adjoining building. One of my students repaired to the distant telephone to observe the effects of articulate speech, while I uttered the sentence, "Do you understand what I say?" into the telephone placed in the lecture-hall. To my delight an answer was returned through the instrument itself, articulate sounds proceeded from the steel spring attached to the membrane, and I heard the sentence, "Yes, I understand you perfectly." It is a mistake, however, to suppose that the articulation was by any means perfect, and expectancy no doubt had a great deal to do with my recognition of the sentence; still, the articulation was there, and I recognized the fact that the indistinctness was en-

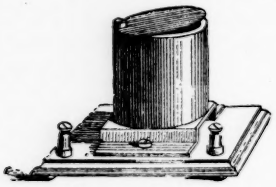


Fig. 25.

tirely due to the imperfection of the instrument. I will not trouble you by detailing the various stages through which the apparatus passed, but shall merely say that after a time I produced the form of instrument shown in Fig. 25, which served very well as a receiving telephone. In this condition my invention was exhibited at the Centennial Exhibition in Philadelphia. The telephone shown in Fig. 24 was used as a transmitting instrument, and that in Fig. 25 as a receiver, so that vocal communication was only established in one direction.

Another form of transmitting telephone exhibited in Philadelphia, intended for use with the receiving telephone (Fig. 25), is represented by Fig. 26.

A platinum wire attached to a stretched membrane completed a voltaic circuit by dipping into water. Upon speaking to the membrane, articulate sounds proceeded from the telephone in the distant room. The sounds produced by the telephone became louder when dilute sulphuric acid, or a saturated solution of salt, was substituted for the water. Audible effects were also produced by the vibration of plumbago in mercury, in a solution of bichrommate of potash, in salt and water, in dilute sulphuric acid, and in pure water.

The articulation produced from the instrument shown in Fig. 25 was remarkably distinct, but its great defect consisted in the fact that it could not be used as a transmitting instrument, and thus two telephones were required at each station, one for transmitting and one for receiving spoken messages.

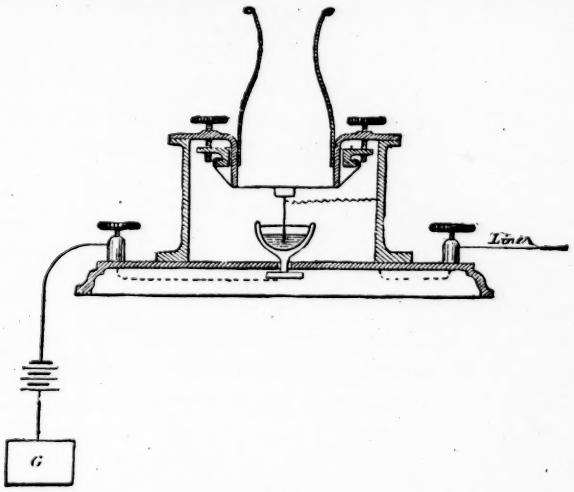


Fig. 26.

It was determined to vary the construction of the telephone shown in Fig. 24, and I sought, by changing the size and tension of the membrane, the diameter and thickness of the steel spring, the size and power of the magnet, and the coils of insulated wire around their poles, to discover empirically the exact effect of each element of the combination, and thus to deduce a more perfect form of apparatus. It was found that a marked increase in the loudness of the sounds resulted from shortening the length of the coils of wire, and by enlarging the iron diaphragm which was glued to the membrane. In the latter case, also, the distinctness of the articulation was improved. Finally, the membrane of goldbeater's skin was discarded entirely, and a simple iron plate was used instead, and at once intelligible articulation was obtained. The new form of instrument is that shown in Fig. 27, and, as had been long anticipated, it was proved that the only use of the battery was to magnetize the iron core of the magnet, for the effects were equally audible when the battery was omitted and a rod of magnetized steel substituted for the iron core of the magnet.

It was my original intention, as shown in Fig. 19, and it was always claimed by me, that the final form of telephone would be

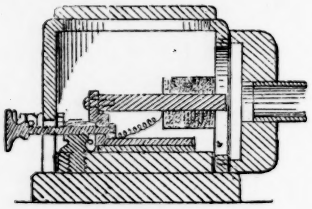


Fig. 27.

operated by permanent magnets in place of batteries, and numerous experiments have been carried on by Mr. Watson and myself privately for the purpose of producing this effect.

At the time the instruments were first exhibited in public the results obtained with permanent magnets were not merely so striking as when a voltaic battery was employed; wherefore we thought it best to exhibit only the latter form of instrument.

The interest excited by the first published accounts of the operation of the telephone led many persons to investigate the subject, and I doubt not that numbers of experimenters have independently discovered that permanent magnets might be employed instead of voltaic batteries. Indeed, one gentleman, Professor Dolbear, of Tuft's College, not only claims to have discovered the magneto-electric telephone, but, I understand, charges me with having obtained the idea from him through the medium of a mutual friend.

A still more powerful form of apparatus was constructed by using a powerful compound horse-shoe magnet in place of the straight rod which had been previously used (see Fig. 28). Indeed

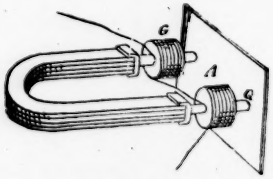


Fig. 28.

the sounds produced by means of this instrument were of sufficient loudness to be faintly audible to a large audience, and in this condition the instrument was exhibited in the Essex Institute in Salem, Massachusetts, on the 12th February, 1877, on which occasion a

short speech shouted into a similar telephone in Boston, sixteen miles away, was heard by the audience in Salem. The tones of the speaker's voice were distinctly audible to an audience of 600 people, but the articulation was only distinct at a distance of about six feet. On the same occasion, also, a report of the lecture was

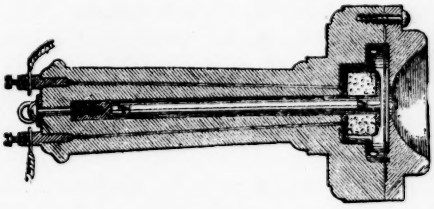


Fig. 29.

transmitted by word of mouth from Salem to Boston, and published in the papers the next morning.

From the form of telephone shown in Fig. 27 to the present form of the instrument (Fig. 29) is but a step. It is in fact the arrangement of Fig. 27 in a portable form, the magnet F H being placed inside the handle, and a more convenient form of mouthpiece provided. The arrangement of these instruments upon a telegraphic circuit is shown in Fig. 30.

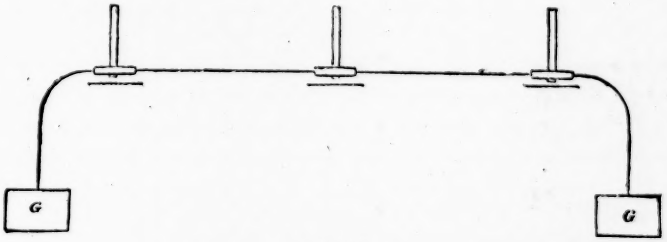


Fig. 30.

And here I wish to express my indebtedness to several scientific friends in America for their co-operation and assistance. I would especially mention Professor Peirce and Professor Blake, of Brown University; Dr. Channing, Mr. Clarke and Mr. Jones. In Providence, Rhode Island, these gentlemen have been carrying on together experiments seeking to perfect the form of apparatus required, and I am happy to record the fact that they communicated

7149

to me each new discovery as it was made, and every new step in their investigation. It was, of course, almost inevitable that these gentlemen should retrace much of the ground that had been gone over by me, and so it has happened that many of their discoveries had been anticipated by my own researches; still the very honorable way in which they from time to time placed before me the results of their discoveries entitles them to my warmest thanks and to my highest esteem. It was always my belief that a certain ratio would be found between the several parts of a telephone, and that the size of the instrument was immaterial; but Professor Peirce was the first to demonstrate the extreme smallness of the magnets which might be employed. And here, in order to show the parallel lines in which we were working, I may mention the fact that two or three days after I had constructed a telephone of the portable form (Fig. 29), containing the magnet inside the handle, Dr. Channing was kind enough to send me a pair of telephones of a similar pattern, which had been invented by the Providence experimenters. The convenient form of mouthpiece shown in Fig. 29, now adopted by me, was invented solely by my friend Professor Peirce. I must also express my obligations to my friend and associate, Mr. Thomas A. Watson, of Salem, Massachusetts, who has for two years past given me his personal assistance in carrying on my researches.

In pursuing my investigations I have ever had one end in view, the practical improvement of electric telegraphy; but I have come across many facts which, while having no direct bearing upon the subject of telegraphy, may yet possess an interest for you.

For instance, I have found that a musical tone proceeds from a piece of plumbago or retort carbon when an intermittent current of electricity is passed through it; and I have observed the most curious audible effects produced by the passage of reversed intermittent currents through the human body. A rheotome was placed in circuit with the primary wires of an induction coil, and the fine wires were connected with two strips of brass. One of these strips was held closely against the ear and a loud sound proceeded from it whenever the other slip was touched with the other hand. The strips of brass were next held one in each hand. The induced currents occasioned a muscular tremor in the fingers. Upon placing my forefinger to my ear a loud crackling noise was audible, seemingly proceeding from the finger itself. A friend who was present placed my finger to his ear, but heard nothing. I requested him to hold the strips himself. He was then distinctly conscious of a noise (which

I was unable to perceive) proceeding from his finger. In this case a portion of the induced currents passed through the head of the observer when he placed his ear against his own finger; and it is possible that the sound was occasioned by a vibration of the surface of the ear and finger in contact.

When two persons receive a shock from a Ruhmkorff coil by clasping hands, each taking hold of one wire of the coil with the free hand, a sound proceeds from the clasped hands. The effect is not produced when the hands are moist. When either of the two touches the body of the other a loud sound comes from the parts in contact. When the arm of one is placed against the arm of the other, the noise produced can be heard at a distance of several feet. In all these cases a slight shock is experienced so long as the contact is preserved. The introduction of a piece of paper between the parts in contact does not materially interfere with the production of the sounds, but the unpleasant effects of the shock are avoided.

When an intermittent current from a Ruhmkorff coil is passed through the arms, a musical note can be perceived when the ear is closely applied to the arm of the person experimented upon. The sound seems to proceed from the muscles of the forearm and from the biceps muscle. Mr. Elisha Gray has also produced audible effects by the passage of electricity through the human body.

An extremely loud musical note is occasioned by the spark of a Ruhmkorff coil, when the primary circuit is made and broken with sufficient rapidity; when two rheotomes of different pitch are caused simultaneously to open and close the primary circuit a double tone proceeds from the spark.

A curious discovery, which may be of interest to you, has been made by Professor Blake. He constructed a telephone in which a rod of soft iron, about six feet in length, was used instead of a permanent magnet. A friend sang a continuous musical tone into the mouthpiece of a telephone, like that shown in Fig. 29, which was connected with the soft iron instrument alluded to above. It was found that the loudness of the sound produced in this telephone varied with the direction in which the iron rod was held, and that the maximum effect was produced when the rod was in the position of the dipping needle. This curious discovery of Professor Blake has been verified by myself.

When a telephone is placed in circuit with a telegraph line, the

telephone is found seemingly to emit sounds on its own account. The most extraordinary noises are often produced, the causes of which are at present very obscure. One class of sounds is produced by the inductive influence of neighboring wires and by leakage from them, the signals of the Morse alphabet passing over neighboring wires being audible in the telephone, and another class can be traced to earth currents upon the wire, a curious modification of this sound revealing the presence of defective joints in the wire.

Professor Blake informs me that he has been able to use the railroad track for conversational purposes in place of a telegraph wire, and he further states that when only one telephone was connected with the track the sounds of Morse operating were distinctly audible in the telephone, although the nearest telegraph wires were at least forty feet distant.

Professor Peirce has observed the most curious sounds produced from a telephone in connection with a telegraph wire during the aurora borealis; and I have just heard of a curious phenomenon lately observed by Dr. Channing. In the City of Providence, Rhode Island, there is an over-house wire about one mile in extent with a telephone at either end. On one occasion the sound of music and singing was faintly audible in one of the telephones. It seemed as if some one were practicing vocal music with a piano-forte accompaniment. The natural supposition was that experiments were being made with the telephone at the other end of the circuit, but upon inquiry this proved not to have been the case. Attention having thus been directed to the phenomenon, a watch was kept upon the instruments, and upon a subsequent occasion the same fact was observed at both ends of the line by Dr. Channing and his friends. It was proved that the sounds continued for about two hours, and usually commenced about the same time. A searching examination of the line disclosed nothing abnormal in its condition, and I am unable to give you any explanation of this curious phenomenon. Dr. Channing has, however, addressed a letter upon the subject to the editor of one of the Providence papers, giving the names of such songs as were recognized, with full details of the observations, in the hope that publicity may lead to the discovery of the performer, and thus afford a solution of the mystery.

My friend, Mr. Frederick A. Gower, communicated to me a curious observation made by him regarding the slight earth connection

required to establish a circuit for the telephone, and together we carried on a series of experiments with rather startling results. We took a couple of telephones and an insulated wire about 100 yards in length into a garden, and were enabled to carry on conversation with the greatest ease when we held in our hands what should have been the earth wire, so that the connection with the ground was formed at either end through our bodies, our feet being clothed with cotton socks and leather boots. The day was fine, and the grass upon which we stood was perfectly dry. Upon standing upon a gravel walk the vocal sounds, though much diminished, were still perfectly intelligible, and the same result occurred when standing upon a brick wall one foot in height, but no sound was audible when one of us stood upon a block of freestone.

One experiment which we made is so very interesting that I must speak of it in detail. Mr. Gower made earth connection at his end of the line by standing upon a grass plot, whilst at the other end of the line I stood upon a wooden board. I requested Mr. Gower to sing a continuous musical note, and to my surprise the sound was very distinctly audible from the telephone in my hand. Upon examining my feet I discovered that a single blade of grass was bent over the edge of the board, and that my foot touched it. The removal of this blade of grass was followed by the cessation of the sound from the telephone, and I found that the moment I touched with the toe of my boot a blade of grass or the petal of a daisy the sound was again audible.

The question will naturally arise, Through what length of wire can the telephone be used? In reply to this I may say that the maximum amount of resistance through which the undulatory current will pass, and yet retain sufficient force to produce an audible sound at the distant end, has yet to be determined; no difficulty has, however, been experienced in laboratory experiments in conversing through a resistance of 60,000 ohms, which has been the maximum at my disposal. On one occasion, not having a rheostat at hand, I may mention having passed the current through the bodies of sixteen persons, who stood hand in hand. The longest length of real telegraph line through which I have attempted to converse has been about 250 miles. On this occasion no difficulty was experienced so long as parallel lines were not in operation. Sunday was chosen as the day on which it was probable other circuits would be at rest. Conversation was carried on between myself, in New York, and Mr. Thomas A. Watson, in Boston, until the

opening of business upon the other wires. When this happened the vocal sounds were very much diminished, but still audible. It seemed, indeed, like talking through a storm. Conversation, though possible, could be carried on with difficulty, owing to the distracting nature of the interfering currents.

I am informed by my friend Mr. Preece that conversation has been successfully carried on through a submarine cable, sixty miles in length, extending from Dartmouth to the Island of Guernsey, by means of hand telephones similar to that shown in Fig. 30.

(No. 79.) Defendants' Exhibit Brevet Scott du 25 mars 1857, No. 31,470, et certificat d'addition du 29 juillet 1859. Expedition.

(Introduced in Case, p. 410.)

Demande d'un brevet d'invention de quinze ans, pris le 25 mars 1857. No. 31,470, pour : Procédé au moyen duquel ou peut écrire et dessiner par le son (acoustique), multiplier graphiquement les résultats obtenus et en faire des applications industrielles, par Mr. Scott.

MEMOIRE DESCRIPTIF.

Le procédé que j'ai inventé consiste à fixer un style simple ou composé vers le centre d'une membrane mince placée à l'extrémité d'un conduit acoustique quelconque.

Ce style affleure légèrement une substance sensible aux plus légers frottements, comme une couche de noir de fumée, par exemple, substance déposée sur un verre, un métal ou même une feuille de papier ou d'étoffe.

La couche sensible passe sous le style avec une vitesse régulière et déterminée, connue cela se pratique dans les expériences ordinares d'acoustique.

Le style trace, quand on parle, qu'on chante ou qu'on joue d'un instrument en présence du conduit acoustiqne, des figures ou des dessins en rapport avec les sons produits.

Je fixe ensuite cette nouvelle graphie par une immersion dans un carbure liquide, suivre d'un bain dans de l'eau albumineuse.

Je tire aussi directement des épreuves dites, "négatives" ou indirectement des épreuves "positives" par la photographie ou le transport sur pierre, etc.

A l'aide de ce procédé et des pièces de rechange du phonautographe, fig. 2, je recueille la trace acoustique de la parole à distance, du chant de la voix et de différents instruments, fig. 3.

Je me propose d'appliquer mon procédé à la construction d'un instrument diviseur, à celle d'un accordeur mathématique de tous les instruments, d'un sténographe de la voix et des instruments à l'étude de conditions de sonorité de diverses substances, et à

produire des dessins industriels pour broderies, filigranes, bijouterie, etc.

La fig. 1, indique nettement le procédé dans sa plus grande simplicité, procédé qui est à peu près indépendant du nombre des membranes minces, de leur grandeur, de la forme et des dimensions du conduit sur lequel elles sont appliquées, du mode de suspension du phonautographe et de la nature du moteur qui imprime la vitesse à la couche sensible.

La grandeur de mes appareils est indéterminée, c'est-à-dire qu'elle s'étend dans les limites de vibration des membranes.

Néanmoins, pour fixer les idées, la fig. 1 peut être supposée de grandeur uaturelle.

n, fig. 1, est une membrane (de caoutchouc mince, de bandruche, de vessie ou de papier préparé), qui reçoit l'impression des vibrations et ondulations du courant sonore amené par le tuyau acoustique. Cette membrane, qui dans certaines applications de la phonautographie peut-être placée perpendiculairement à l'axe du conduit, est oblique dans mes dispositions, afin de s'impressioner des ondes dites "d'inflexion."

a est un anneau tendeur, mobile, supposé appliqué à toutes les membranes du phonautographe et qui sert à leur donner le degré de tension voulu.

d est le directeur du style ; c'est un petit cylindre de matière très-légère, perforé suivant son axe et collé à la membrane. Il est destiné à recevoir le style et à le maintenir dans une direction fixe et déterminée.

Le style simple ou composé écrit les mouvements de la membrane sur la couche sensible mobile.

La couche sensible est formée de noir de fumée ou d'une autre substance colorante déposée par volutilisation sur un papier, une étoffe ou une plaque de métal ou de verre.

L'infundibulum, fig. 2, présente diverses formes, selon le but spécial qu'on se propose : Ainsi on peut recueillir des sons forts ou faibles, proches ou un peu plus éloignés, obtenir l'écriture, la sténographie du chant ou la production de dessins.

L'extrémité inférieure de chaque infundibulum est armée d'une membrane, perforée ou non selon les cas, qui s'approche ou s'éloigne de l'orifice de l'infundibulum au moyen d'un tirage, et peut ainsi être située ou non sur un ventre ou un nœud de vibration.

A, est une pièce composée, qui est la même pour les différents infundibulums, pièce tronc conique ou cylindrique, elliptique, et

formée de tubes recuvrants, d'un second tirage et d'une membrane avec son anneau et son style, membrane analogue de la fenêtre ovale de l'ouië.

Le tirage de cette pièce, réglé par une vis graduée, est destiné à comprimer l'air entre les membranes, si elles ne sont pas perforées, et à régler la longueur du tuyau pour les sons graves ou aigus propres aux différents instruments.

B, caisse à air ou caisse du tympan pour augmenter l'intensité des sons et la sensibilité des membranes pour les sons faibles ou éloignés.

Dans cette figure, les tirages, au nombre de trois, agissent dans des limites étendues et font varier, selon le besoin, la capacité intérieure de l'instrument et sa longueur.

T, tirages appliqués à des parties cylindriques ou faiblement coniques, et qui doivent être, autant que faire se peut, imperméables à l'air. Ils s'opèrent par glissement de surfaces polies les unes sur les autres et sont réglés par une vis de graduation.

Dans la fig. 3 on voit que la couche sensible passe sous le style mis en mouvement par l'action d'une trompette à distance, avec une vitesse déterminée par le mouvement d'une pendule et que rend uniforme un moteur emprunte à l'horlogerie ou à l'électricité, moteur qui n'est pas représenté dans la figure.

Demande d'un certificat d'addition, en date du 29 juillet 1859, au brevet d'invention de quinze ans, pris le 25 mars 1857, No. 31,470, pour: Procédé au moyen du quel on peut écrire et dessiner par le son (acoustique), multiplier graphiquement les résultats obtenus et en faire des applications industrielles, par Mr. Scott.

Memoire Descriptif.

Par la phonautographie, on se propose d'obtenir facilement une impression correcte des mouvements rapides et spécialement des mouvements vibratoires qui s'accomplissent dans l'air et qui sont produits par des agents quelconques, mécaniques, physiques ou physiologiques, et entre autres par les instruments d'acoustique, de musique, ou même les voix.

Le brevet d'invention repose essentiellement sur trois moyens

qui, soit séparément, soit par leur réunion, sont l'âme des divers appareils dont se compose la phonautographie.

Ces trois moyens sont :

1°. L'application d'un style sur une membrane placée à l'extrémité d'un conduit dont les formes peuvent varier selon l'objet spécial qu'on a en vise.

2°. L'emploi d'un style souple, d'origine animale ou végétale, et composé d'une ou plusieurs parties.

3°. La fixation, au moyen d'un ou de plusieurs bains chimiques, du tracé obtenu sur un papier ou tissu revêtu d'une couche d'un noir de lampe spécial.

J'insiste sur ce point que ces moyens constituent trois applications qu'on peut faire aux sciences et aux arts isolément ou combinées deux à deux.

Par exemple, le style peut être adapté à un être ou à un objet en mouvement pour inscrire sur la couche sensible ses déplacements et les mesurer, ou bien sur des moteurs ou des mécanismes très-variés.

La fixation du noir de lampe impressionné permet de conserver la trace des mouvements d'agents animés ou inanimés et des dessins naturels tellement subtile qu'on n'aurait pu se les procurer autrement.

Ces trois moyens réunis, et appropriés par différentes dispositions à la nature des phénomènes qu'on se propose d'enregistrer, suffisent pour obtenir une image graphique, fidèle et détaillée d'un très-grand nombre de phénomènes produits dans l'air qui nous environne.

On concevra sans peine combien il est curieux, au point de vue de la science, de conserver la représentation exacte des phases par lesquelles passe un phénomène qu'on avait cru simple pendant un intervalle de temps insaisissable à nos sens par sa brièveté, quelques millièmes de seconde seulement.

La phonautographie, par exemple, met aux mains des physiciens et des physiologistes un diagramme naturel des états successifs ou simultanés des corps qui sont la cause primitive de nos sensations.

La plupart de ces mouvements sont si délicats et si rapides, que leur inscription sur une couche sensible présentait les plus grandes difficultés.

Le frottement du pinceau le plus léger en marque entièrement la loi.

J'ai donc dû adopter en phonotographie un style ferme et souple à la fois, sans poids appréciable, complètement différent sous ce rapport du style métallique employé par Monsieur Wertheim pour écrire les vibrations des solides.

Le style phonautographique à pointe très-fixe, marque, par une sorte de balayage ; sa trace sur une couche mince de noir de lampe produite par une huile spéciale et déposée par voie de sublimation. Etant suspendu à l'état semi-fluide, ce noir n'a presque aucune adhérence avec le papier ou tissu qui l'arrête pendant son ascension.

L'image phonautographique aussitôt formée est fixée par le procédé décrit dans le brevet et plus spécialement ci-dessous. Elle peut être ensuite multipliée, s'il y a lieu, par les moyens connus.

J'avais appliqué un moteur à mouvement uniforme pour communiquer un va-et-vient progressif et régulier à cette couche.

J'ai reconnu que depuis, pour un très-grand nombre d'applications, ou pouvait se contenter du mouvement continu d'un cylindre mû par une vis en hélice s'avançant dans une écrou fixe.

Cette disposition est employée dans les cours de physique.

L'expérimentateur est dispensé de l'uniformité de mouvement de la couche sensible ; il lui suffit alors, pour compter le temps ou mesurer la durée d'un phénomène, si court qu'il soit, de faire pointer simultanément sur le cylindre en mouvement un chronomètre à secondes ou un diapason armé du style souple et étalonné à une nombre déterminé de vibrations, par exemple, 1000 ou 500 par seconde.

J'ai ajouté depuis la prise du brevet à l'anneau tenseur de la membrane une pièce d'abord nommée " manche du marteau," par analogie avec une disposition analogue de l'organe de l'ouïe, mais que j'appellerai aujourd'hui, pour plus d'exactitude, le subdiviseur de la membrane.

Cette pièce sert à déterminer dans la membrane des lignes nodales, telles qu'elles permettent d'écrire un son pour lequel, sans le secours de ce dispositif, le style se fût trouvé placé sur un nœud de vibration de cette membrane.

Une difficulté grave était à vaincre pour réunir convenablement les ondes sonores sur la membrane. Les conduits sont d'autant plus impropres à conduire les voix qu'ils vibrent plus facilement.

Dans un tel conduit, une partie notable de la vibration de fluide se transforme par voie de communication en vibration de solide, et perd ainsi beaucoup de sa force vive initiale.

Si même le conduit est un peu long, la membrane peut demeurer presque insensible à un son d'intensité médiocre. J'ai donc dû m'arrêter aux conduits faits de matières insonores (plâtre coule ou pâtes solidifiées) et leur donner une certaine épaisseur.

Le mode de procéder, pour obtenir des épreuves phonautographiques, est très-simple. On enroule, en la tendant, une bande de papier sur le cylindre. On charge ce papier, qui tourne avec une vitesse à peu près uniforme, d'une couche égale, opaque, excessivement mince, de noir de fumée.

Vers le centre de la membrane est placé le style, dont l'extrémité qui trace est tirée d'une plume de certains oiseaux.

Cette pointe si teinse obéit à tous les mouvements simples ou complexes de la membrane.

Dans cet état, on présente le style au cylindre de la manière qu'il l'effleure tout en restant invariable dans la direction de sa lampe.

On fait entendre le son à l'ouverture de la cuve ou conduit, la membrane entre en vibration, le style suit ses mouvements et son extrémité trace sur le cylindre qui décrit une hélice continue les figures de la vibration de son produit. Elles en marquent le nombre et le timbre.

Ces figures sont amples quand le son est intense, microscopiques s'il est très-faible, écartées quand il est grave, serrées s'il est aigu, d'un dessin régulier et franc si le timbre est pur, inégales et comme tremblées s'il est mauvais ou voilé.

Voici maintenant la série d'expériences intéressantes pour les physiciens, les physiologistes, les facteurs d'instruments, les amateur de sciences, qu'on peut déjà exécuter avec l'appareil.

1°. Ecrire le mouvement vibratoire d'un solide quelconque pour servir de terme de comparaison avec les mouvements d'un fluide; compter les nombre des vibrations exécutées par ce solide dans l'unité de temps au moyen du chronomètre pointeur.

2°. Un diapason ayant, par le moyen de l'expérience précédente, été étalonné à un nombre déterminé de vibrations dans l'unité de temps (500 à 1,000 par exemple), compter, en les faisant écrire simultanément, le nombre de vibrations accomplies par tout agent capable de vibrer (solide ou fluide) dans un espace de temps aussi court l'on voudra (quelqes millièmes de seconde).

Exemple: Compter et mesurer les phases diverses d'un bruit et les intervalles de temps compris entre des phénomènes sonores

rapides et successifs ; éprouver la sonorité relative des métaux, des alliages, des bois, etc.

3°. Ecrire les vibrations produites dans une membrane par un ou plusieurs tuyaux sonnant simultanément ; en compter le nombre, en montrer les phases ; obtenir la figure ou diagramme acoustique de chacun des accords et des dissonances ; écrire de même le haut d'instruments à vent quelconques, montrer le timbre propre de ces instruments, écrire le mouvement composé résultant des sons de deux ou de plusieurs instruments jouant simultanément.

4°. Ecrire le chant d'une voix, en mesurer l'étendue par le chronomètre pointeur ou le diapason étalon-pointeur ; écrire la gamme d'un chanteur ; en mesurer la justesse par le diapason pointeur, en montrer la pureté ou l'isochromisme des vibrations, ainsi que le timbre ; écrire une mélodie et la transcrire à l'aide du diapason pointeur, écrire le chant simultané de deux voix et en montrer l'accord ou le désaccord.

5°. Etudier acoustiquement les mouvements physiologiques ou patologiques de l'appareil vocal et de ses parties pendant les différentes émissions du son, le cri, etc., marquer le timbre propre à une voix donnée.

6°. Etudier la voix articulée, la déclamation ; montrer les diagrammes syllabiques.

7°. Inscrire par la réunion du deuxième moyen (le style flexible) et du troisième (la fixation) les mouvements du pendule, du touton ou toupie, de l'aiguille aimantée, le mode de locomotion d'un insecte, etc.

8°. Ecrire au moyen d'un conduit acoustique de plusieurs centaines de mètres de longueur des sons ou des signaux produits à des distances plus ou moins étendues.

9°. Ecrire, sans le secours de conduits, des signaux produits sous une eau tranquille à des stations éloignées de plusieurs kilomètres.

1. LE CYLINDRE ET SON MOUVEMENT.

L'axe du cylindre est en fer.

L'une de ses extremités est une hélice chariotée en acier.

L'écrou et le coussinet sont en cuivre.

Une disposition de l'écrou permet de rendre la liberté au cylindre pendant l'opération du noircissage. Le bâti qui le supporte est en forte et fixé à vis dans le plateau de chêne qui sert

de base à tout l'appareil. Le pas de l'hélice permet de faire écrire le chronomètre ou le diapason dans l'interligne.

Le cylindre est mû à la main par une manivelle, disposition qui donne le moyen de ralentir ou d'accélérer le mouvement suivant le degré de rapidité du tracé à obtenir.

2. CHRONOMETRE ET SON SUPPORT.

Le chronomètre pointeur employé dans l'appareil et destiné à étalonner un son de solide ou de fluide est celui imaginé par M. Redier.

Une pointe préparée pour cet office porte un style souple qui est mis en contact avec le cylindre dans l'entreligne du tracé phonautographique.

Un échappement le relève pendant une durée de six secondes.

On obtient ainsi sur chaque bande des sérrés de six secondes ; le sixième de chacune est le nombre de vibrations exécutées en une seconde de temps.

Le support du chronomètre possède tous les mouvements et glisse librement en tous sens sur le plateau qui porte l'appareil.

On comprendra que tout autre chronomètre pointeur ou tout autre support pouvait être employé, est que c'est le pointage même du temps sur le cylindre au moyen d'un chronomètre qui fait l'objet de la présente addition,

3. LE DIAPASON POINTEUR ET SON SUPPORT.

Ce diapason pointeur, étalonné à une nombre de vibrations mutiple de 500 à 1,000, par exemple, remplit le même office que le chronomètre. Seulement, au lieu de compter les secondes, ce sont les millièmes de seconde qu'il indique en entreligne sur le cylindre. Il fournit ainsi le moyen de compter les bruits, les sons ou les signaux d'une extrême brièveté. Il devra être tenu à une distance de la membrane suffisante pour qu'elle ne soit pas influencée par ses vibrations. Ce diapason est monté dans un support analogue à celui du chronomètre.

4. LA MEMBRANE ET SON APPAREIL DE TENSION.

La matière de la membrane peut changer avec le but qu'on se propose.

On emploie également bien la bandruche, le cautchouc soufflé, la vessie, un velin animal, ou même le collodion.

Il est souvent utile, pour leur donner de la sonplesse et remédier à l'hygroscopicité, d'enduire les membranes de glycérine.

L'anneau préhenseur de la membrane, que j'appelle aujourd'hui "tenseur," et le directeur du style, que j'appele "subdiviseur de la membrane," diffèrent en quelques points de ce qui est figuré dans le brevet.

La membrane est amenée à l'état de tension convenable au moyen de deux anneaux sur l'un desquels elle est fixée.

Les deux anneaux se rapprochent ou s'écartent au moyen de vis dans les timbales.

Le subdiviseur de la membrane est fixé à l'anneau inférieur ; il se compose d'une petite planchette mobile à rainure qui reçoit à l'un de ses bouts une vis destinée à s'enfoncer plus ou moins dans la membrane.

Cette planchette et son support sont fixés dans la position requise au moyen de vis.

L'anneau qui porte la membrane tourne à frottement sur un tuyau court et condé.

Ce dernier ajustement est destiné à donner à la membrane une inclination convenable sur l'axe de tuyau court.

Ce tuyau glisse lui-même à frottement dans l'orifice de la cuve qui fait face au cylindre.

On obtient au moyen de ces dispositions toutes les directions et les différentes approches du style sans déplacement de la cuve.

5. LE STYEE SOUPLE.

Le style est formé de l'extrémité de la barbule d'une plume, collée sur une hampe non-élastique prise dans la portion médiane d'une organe flexible qu'on trouve chez certains crustacés, les grosses crevettes, par exemple.

On comprend que l'emploi de ces deux subtances particulières n'est pas de rigueur et que j'ai dû indiquer les substances d'origine végétale ou animale jouissant des mêmes propriétés.

La division du style en deux parties de nature différente m'a paru très-importante pour le bon succès des opérations, et j'y insiste dans ces certificats.

2763

6. CUVE ET SON SUPPORT.

Cette cuve doit être, comme je l'ai expliqué, d'une matière aussi insonore que possible et d'une certaine épaisseur.

Ces formes, ainsi que je l'ai dit dans le brevet peuvent être variées, afin de s'approprier au but spécial qu'on se propose.

Ainsi elle peut-être une simple cupule annexée au tuyau court de la membrane pour étudier, par exemple, le timbre de la voix et l'articulation ; un conduit modelé sur la forme du conduit auditif externe de l'oreille, pour des études particulièrement physiologique ; un vaste cornet acoustique, un paraboloïde de révolution, etc.

La cuve de l'appareil construit est une portion d'ellipsoïde de révolution coulée en plâtre stuqué.

L'orifice qui communique avec la membrane occupe un des foyers de l'ellipsoïde et l'agent producteur du son est vers l'autre foyer situé en avant de la cuve et à l'air libre, ce qui offre l'avantage de ne pas altérer le timbre comme dans les cas ou le son est produit dans la cuve même.

Cette cuve a paru très convenable, en ce sens qu'elle s'adapte à un grand nombre d'expériences et permet de présenter plusieurs instruments devant son entrée.

Le brevet comprend, néanmoins, tout conduit à l'extrémité duquel on peut placer une membrane arinée d'un style.

Le support de la cuve est coulé en fonte ; il se compose d'une sorte de crénaillière oblique qui permet d'élever la cuve ou de la descendre à volonté. La branche antérieure du support porte une vis calante au moyen de laquelle on élève l'orifice de la cuve portant la membrane à la hauteur requise.

7. LA LAMPE FUMEUSE ET LE NOIR SPECIAL.

J'emploie une lampe sans courant d'air ; elle porte une grande et large mèche plate.

Le noir de lampe est obtenu par un mélange de deux tiers environ d'huile à brûler non épurée et d'un tiers d'huile de résine de deuxième distillation.

Il faut veiller au bon état de la mèche et remuer le mélange à chaque opération, car l'huile de résine, plus lourde que l'huile ordinaire, se précipite au fond.

Pour noircir, on fait tourner le cylindre et l'on promène sa lampe allumée à 7 ou 8 centimètres au-dessous du papier tendu.

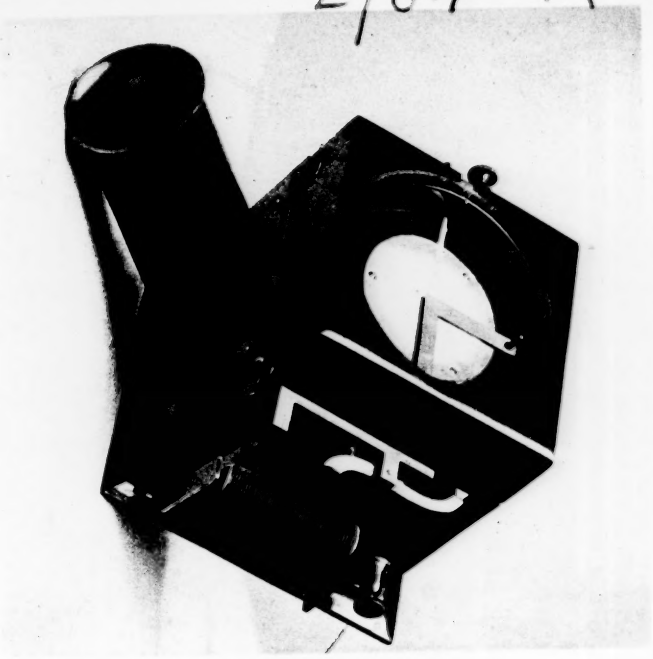
2764

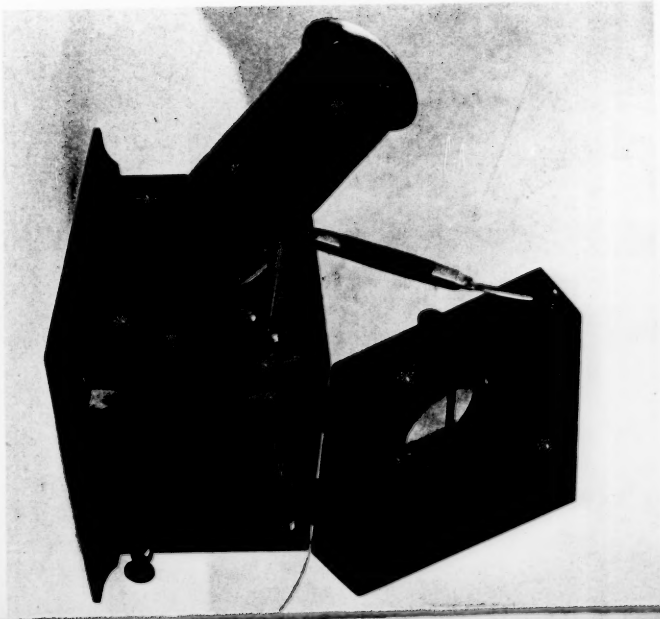
8. FIXATION DES EPREUVES.

Elle s'obtient par un trempage fait avec précaution dans un premier bain d'alcohol pur ; l'épreuve, ayant reçu ce commencement de fixation et étant sèchée, est ensuite enduite au moyen de la solution d'une résine dans l'acohol.

La sandaraque réussit bien comme fixatif et remplace avec avantage l'eau albumineuse.

2764 A.





WASHINGTON, D. C.,
May 28, 1881.

No. 1.

I hereby certify that this is a photograph of the Reis Telephon
now in the Smithsonian Institution.

WM. J. GREEN.

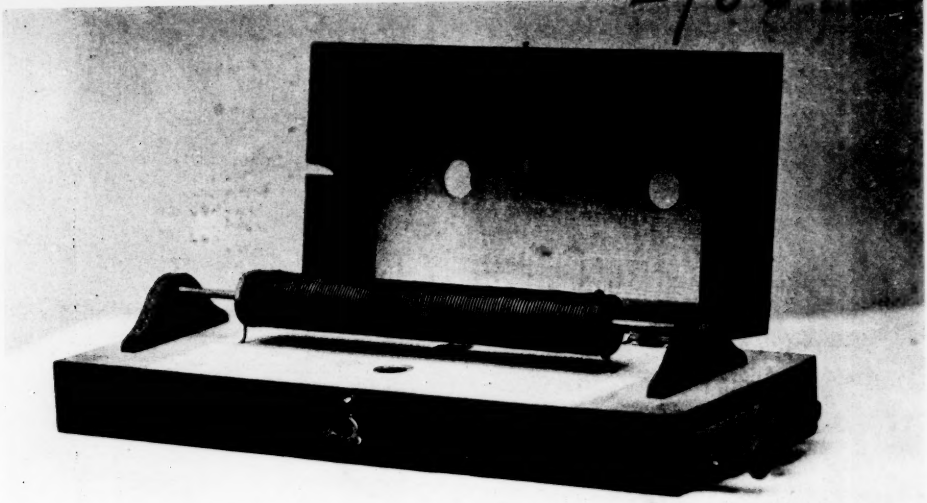
Witness:
J. M. YZNAGA.

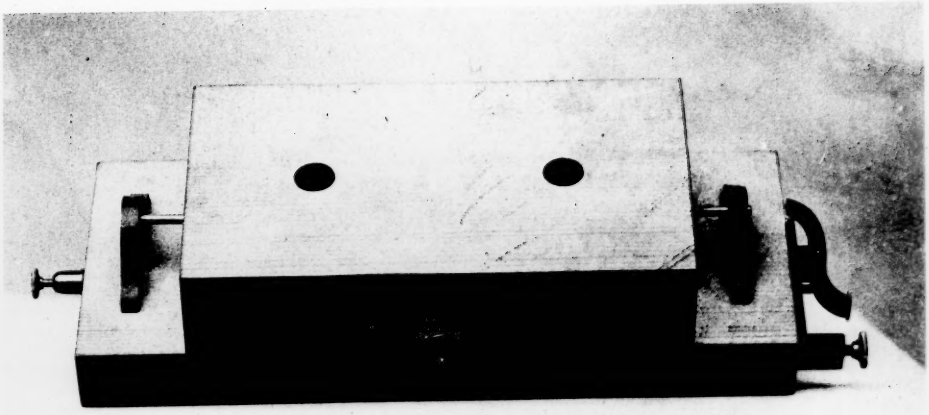
Defendant's Exhibit Smithsonian Reis Transmitter
View 1.

J. A. WELCH, Sp'l Examiner.

[Introduced in Case, p. 45].

2765 B.





WASHINGTON, D. C.

No. 3.

I hereby certify that this is a photograph of the Reis Telephon
now in the Smithsonian Institution.

W. J. GREEN.

Witness:
J. M. YZNAGO.

**Defendant's Exhibit Smithsonian Reis Receiver
View 2.**

J. A. WELCH, Sp. Ex'r.

[Introduced in Case, p. 45].

2767

(No. 82. Defendants' Exhibit from "Yearly Report of the Physical Society" of FRANKFURT a. M.)

AUS DER NATUR.—Vol. XXI, page 470.

J. A. W., Sp. Exr., Dec. 4, '84.

Ueber Telephonie durch den galvanischen Strom.

Von **Philipp Reis.**

Die überraschenden Ergebnisse im Gebiete der Telegraphie haben wohl schon oft die Frage angeregt, ob es nicht auch möglich sei, die Tonsprache selbst direct in die Ferne mitzutheilen. Die dahin zielenden Versuche konnten jedoch bis jetzt ein einigermaßen befriedigendes Resultat nicht liefern, weil die Schwingungen schallleitender Medien bald so sehr an Intensität abnehmen, daß sie für unsere Sinne nicht mehr wahrnehmbar sind.

An eine Reproduction der Töne in gewissen Entfernungen durch Hülfe des galvanischen Stromes hat man vielleicht gedacht; aber an der praktischen Lösung dieses Problems haben jedenfalls grade diejenigen am meisten gezweifelt, welche durch ihre Kenntnisse und Hülfsmittel befähigt gewesen wären, die Aufgabe anzugreifen. — Dem mit der Lehre der Physik nur oberflächlich Bekannten scheint die Aufgabe, wenn er dieselbe überhaupt kennt, weit weniger Schwierigkeiten zu bieten, weil er eben die meisten nicht voraussieht. So hatte auch ich vor etwa 9 Jahren (mit viel Begeisterung für das Neue und nur unzureichenden Kenntnissen in der Physik) die Kühnheit, die erwähnte Aufgabe lösen zu wollen, mußte aber bald davon abstehen, weil gleich der erste Versuch mich von der Unmöglichkeit der Lösung fest überzeugte.

Später, nach weiteren Studien und manchen Erfahrungen, sah ich wohl ein, daß mein erster Versuch ein sehr roher, keineswegs überzeugender gewesen; ich griff aber die Frage in der Folge nicht wieder ernstlich auf, weil ich mich den Hindernissen des zu betretenden Weges nicht gewachsen fühlte.

Jugendeindrücke sind aber stark und daher nicht leicht zu verwischen. Ich konnte den Gedanken an jenen Erstlingsversuch und seine Veranlassung trotz

aller Einsprache des Verstandes nicht los werden, und so wurde denn, halb ohne es zu wollen, in mancher Musestunde das Jugendproject wieder durchgenommen, die Schwierigkeiten und die Hülfsmittel zu deren Ueberwindung abgewogen und — zum Experiment vorerst noch nicht geschritten.

Wie sollte ein einziges Instrument die Gesammtwirkungen aller bei der menschlichen Sprache bethätigten Organe zugleich reproduciren? Dieses war immer die Cardinalfrage. Endlich kam ich auf den Einfall, diese Frage anders zu stellen:

Wie nimmt unser Ohr die Gesammtschwingungen aller zugleich thätigen Sprachorgane wahr? Oder allgemeiner genommen:

Wie nehmen wir die Schwingungen mehrerer zugleich tönender Körper wahr?

Um diese Frage zu beantworten, wollen wir zunächst sehen, was geschehen muß, damit wir einen einzelnen Ton wahrnehmen.

Ohne unser Ohr ist jeder Ton nichts, als eine in der Secunde mehreremal (mindestens 7—8) wiederholte Verdichtung und Verdünnung eines Körpers. Findet dieses in demselben Medium statt, in dem wir uns befinden, so wird die Membrane unseres Ohres bei jeder Verdichtung nach der Paukenhöhle zu gedrängt, um bei der nachfolgenden Verdünnung sich nach der entgegengesetzten Seite zu bewegen. Diese Schwingungen bedingen ein mit derselben Geschwindigkeit erfolgendes Aufheben und Niederfallen des Hammers auf den Amboß (nach Anderen: Annäherung und Entfernung der Gehörknöchelatome) und eine ebenso große Anzahl von Erschütterungen der Schneckenflüssigkeit, in welcher der Gehörnerv mit seinen Enden sich ausbreitet. Je größer die Verdichtung des schallleitenden Mediums in einem gegebenen Moment, desto größer die Schwingungsamplitude der Membrane und des Hammers, desto kräftiger folglich der Schlag auf den Amboß und die Erschütterung der Nerven durch Vermittelung der Flüssigkeit. —

Die Bestimmung der Gehörwerkzeuge ist es demnach, jede in dem sie umgebenden Medium entstehende Verdichtung und Verdünnung bis zu dem Gehörnerv mit Sicherheit zu übermitteln. Die Bestimmung des Gehörnervs aber, die in gegebener Zeit erfolgten Schwingungen der Materie, sowohl der Zahl als der Größe nach, zu unserem Bewußtsein zu bringen. — Hier erst wird gewissen Combinationen ein bestimmter Name; hier erst werden die Schwingungen Töne oder Mißtöne.

Das vom Gehörnerv Empfundene ist demnach einfach die zu unserem Bewußtsein gelangende Wirkung einer Kraft, und diese läßt sich nach Dauer und Größe durch eine Curve graphisch darstellen:

Die Linie ab bezeichne uns eine beliebige Zeitdauer und die Curve über

der Linie Verdichtung (+), die Curve unter der Linie Verdünnung (—), so gibt uns jede am Ende einer Abscisse errichtete Ordinate die Verdichtungsstärke

in dem durch ihren Fußpunkt bezeichneten Moment, in Folge deren das Trommelfell schwingt.

Etwas mehr, als das durch ähnliche Curven Darstellbare kann unser Ohr schlechterdings nicht wahrnehmen und genügt dieses auch vollkommen, um uns jeden Ton und jede Tonverbindung zum klaren Bewußtsein zu bringen.

Wenn mehrere Töne zu gleicher Zeit erzeugt werden, so steht das schalleitende Medium unter dem Einflusse mehrerer gleichzeitiger Kräfte und es gelten folgende zwei Gesetze:

Wirken die Kräfte alle in demselben Sinne, so ist die Bewegungsgröße proportional der Summe der Kräfte. Wirken die Kräfte nach entgegengesetzten Richtungen, so ist die Bewegungsgröße proportional der Differenz der entgegenwirkenden Kräfte.

Stellen wir etwa für drei Töne die Verdichtungs-Curve jedes einzelnen dar (Taf. I.), so können wir durch Summirung der Ordinatengleicher Abscissen neue Ordinaten bestimmen und eine neue Curve entwickeln, welche wir Combinationskurve nennen wollen. Diese gibt uns nun ganz genau an, was unser Ohr von den drei gleichzeitigen Tönen empfindet. Daß ein Musiker die drei Töne wieder herauskennt, dürfte uns dabei ebensowenig wundern, als die Thatsache, daß ein mit der Farbenlehre Vertrauter aus Grün, Blau und Gelb wiederfindet; die Combinationscurven von Taf. I. zeigen aber diese Schwierigkeit sehr gering, da in denselben alle Verhältnisse der Componenten successive wiederkehren. Bei Accorden von mehr als drei Tönen (Taf. II.) sind die Verhältnisse allerdings in der Zeichnung nicht mehr so leicht zu zu erkennen. Es fällt aber auch dem geübten Musiker schon schwer, in solchen Accorden die Einzeltöne wieder zu bestimmen.

Taf. III. zeigt uns eine Dissonanz. Warum uns Dissonanzen gerade unangenehm berühren, überlasse ich einstweilen der Anschauungsweise der geehrten Leser, um später in einem anderen Aufsatze vielleicht darauf zurückzukommen.

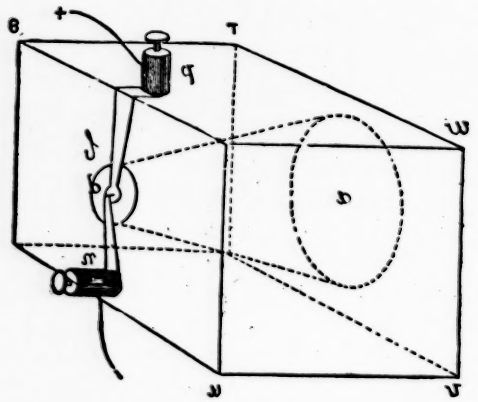
Aus dem Vorhergehenden folgt:

1) Jeder Ton und jede Tonverbindung erzeugt in unserem Gehör, wenn sie dasselbe trifft, Schwingungen des Trommelfells, deren Gang durch eine Curve dargestellt werden kann.

2) Der Gang dieser Schwingungen allein bringt in uns den Begriff (die Empfindung) des Tones hervor und jede Gangänderung muß den Begriff (die Empfindung) ändern.

Sobald es also möglich sein wird, irgendwo und auf irgend eine Weise Schwingungen zu erzeugen, deren Curven denjenigen eines bestimmten Tones oder einer Tonverbindung gleich sind, so werden wir denselben Eindruck haben, den der Ton oder die Tonverbindung auf uns gemacht hätte.

Fußend auf obigen Prinzipien, ist es mir nun gelungen, einen Apparat zu construiren, mit welchem ich im Stande bin, Töne verschiedener Instrumente, ja bis zu einem gewissen Grade die menschliche Stimme zu reproduciren. Derselbe ist sehr einfach und wird mit Hülfe der Fig. durch Folgendes klar erläutert werden:



An dem Holzwürfel r s t u v w x ist die conische Höhlung a durch die Membrane b (aus Schweinsdünndarm) einerseits verschlossen, auf deren Mitte ein stromleitendes Streifchen Platin festgekittet ist. Dieses steht mit der Klemme p in Verbindung. Von Klemme n führt ebenfalls ein dünnes Metallstreifchen über die Mitte der Membrane und endigt hier in ein rechtwinkelig zu seiner Längenare und Breitseite stehendes Platindrähtchen.

Von Klemme p führt ein Leiter durch die Batterie nach einer entfernten Station, endigt dort in eine Spirale von mit Seide umsponnenen Kupferdraht, die ihrerseits in den zur Klemme a führenden Rückleiter mündet.

Die Spirale der entfernten Station ist circa 6″ lang, trägt 6 Lagen dünnen Draht und nimmt in der Mitte einen Strickdraht als Kern auf, der

2771

auf beiden Seiten circa 2″ vorsteht. Mit den vorstehenden Enden des Drahtes ruht die Spirale auf zwei Stegen eines Resonanzbodens. (Dieser ganze Theil kann natürlich durch jeden Apparat ersetzt werden, mittelst dessen man das bekannte „Tönen durch Galvanismus" hervorbringt.)

Werden nun Töne oder Tonverbindungen in der Nähe des Würfels so hervorgebracht, daß noch hinreichend starke Wellen in die Oeffnung a treten, so bringen dieselben die Membrane b in Schwingungen. Bei der ersten Verdichtung wird das hammerförmige Drähtchen d zurückgedrängt; bei der Verdünnung kann dasselbe der zurückschwingenden Membrane nicht folgen und der durch die Streifchen gehende Strom bleibt so lange unterbrochen, bis die Membrane, durch eine neue Verdichtung getrieben, das Streifchen (von p) wieder an d drängt. In dieser Weise bringt jede Schallwelle ein Oeffnen und ein Schließen des Stromes hervor.

Bei jedem Schließen der Kette werden aber in dem Eisendrahte der entfernten Spirale die Atome von einander entfernt (Pouillet Müller S. 304 des 2. B. der 5. Aufl.). Beim Unterbrechen des Stromes suchen dieselben ihre Gleichgewichtslage wieder zu erreichen. Ist dies geschehen, so machen sie in Folge der Wechselwirkung von Elastizität und Trägheit eine Anzahl Schwingungen und geben den Longitudinalton des Stabes. (Siehe wie oben.) So verhält es sich, wenn die Unterbrechungen und Schließungen des Stromes verhältnißmäßig langsam vorgenommen werden. Erfolgen dieselben aber schneller auf einander als die durch die Elastizität bedingten Oscillationen des Eisenkernes, so können die Atome ihre Bahnen nicht vollständig durchlaufen. Die zurückgelegten Wege werden um so kürzer, je rascher die Unterbrechungen folgen, dafür aber eben so häufig, als diese. Der Eisenstab gibt nicht mehr seinen Longitudinalton, sondern einen Ton, dessen Höhe oder Tiefe der Unterbrechungsanzahl (in gegebener Zeit) entspricht. — Das will aber nichts Anderes sagen, als: der Stab reproducirt den Ton, der dem Unterbrechungsapparat zugeführt wurde. — Auch die Stärke dieses Tones steht im Verhältniß zum Originalton, denn, je stärker dieser, desto größer die Bewegungen des Trommelfells, desto größer die Bewegung des Hämmerchens, desto größer endlich die Zeitdauer, während welcher die Kette geöffnet bleibt und folglich desto größer, bis zu einer gewissen Grenze, die Bewegung der Atome in dem Reproductionsdraht, welche wir als größere Schwingung empfinden, ganz so, wie wir die Originalwelle empfunden haben würden.

Da die Länge des Leitungsdrahtes hierbei jedenfalls ebenso weit ausgedehnt werden darf, wie bei directer Telegraphie, so gebe ich meinem Instrumente den Namen „Telephon".

Was nun die Leistungen des Telephons anbelangt, so sei bemerkt, daß ich damit im Stande war, den Mitgliedern einer zahlreichen Versammlung (des physikalischen Vereins zu Frankfurt a. M.) Melodien hörbar zu machen, welche in einem andern Hause (circa 300′ entfernt) bei geschlossenen Thüren (nicht sehr laut) in den Apparat gesungen wurden.

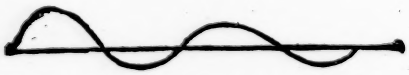
Andere Versuche ergaben, daß der tönende Stab im Stande ist, vollständige Dreiklänge eines Claviers, auf dem das Telephon steht, zu reproduciren, und daß endlich derselbe ebensogut die Töne anderer Instrumente: Harmonika, Clarinette, Horn, Orgelpfeife ꝛc. wiedergiebt, vorausgesetzt, daß die Töne einer gewissen Lage von F—$\overline{\text{f}}$ circa angehören.

Daß bei allen Versuchen hinreichend controlirt wurde, ob directe Schall*leitung* nicht mit im Spiel, versteht sich von selbst. Es geschieht diese Controle sehr einfach durch zeitweise Herstellung einer guten Nebenschließung unmittelbar vor der Spirale, wodurch natürlich die Wirksamkeit derselben momentan aufhört.

Es war bis jetzt nicht möglich, die Tonsprache des Menschen mit einer für Jeden hinreichenden Deutlichkeit wiederzugeben. — Die Consonanten werden größtentheils ziemlich deutlich reproducirt, aber die Vokale noch nicht im gleichen Grade. Woran dieses liegt, will ich versuchen zu erklären.

Nach Versuchen von Willis, Helmholz und Andern können Vokaltöne künstlich hervorgebracht werden, indem man die Schwingungen eines Körpers zeitweise durch die eines anderen verstärken läßt, etwa nach folgendem Schema:

Eine elastische Feder wird durch den Stoß eines Radzahnes in Schwingungen versetzt: die erste Schwingung ist die größte, jede andere immer kleiner als die ihr vorhergehende (Fig.)



Kommt nach einigen Schwingungen dieser Art (ohne daß die Feder vorher zur Ruhe kommt) ein neuer Zahnstoß, so wird die nächstfolgende Schwingung wieder eine größte sein und so fort.

Die Höhe oder Tiefe des auf diese Weise erzeugten Tones hängt von der Anzahl der in einer gegebenen Zeit gemachten Schwingungen ab; der Charakter des Tones aber von der Anzahl der Anschwellungen (Zahnstöße) in derselben Zeit. — Zwei Vokale würden sich bei gleicher Tonhöhe etwa auf

die durch die Curven (Fig. 1, 2) angedeutete Weise unterscheiden, während derselbe Ton ohne Vokalcharakter durch die Curve (Fig. 3) dargestellt würde.

Fig. 1.

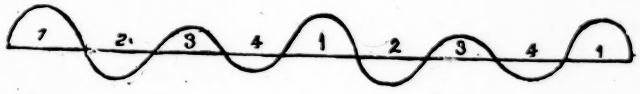


Fig. 2.

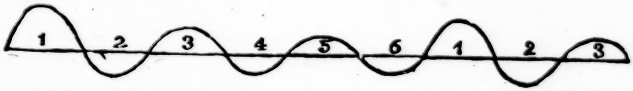


Fig. 3.

Unsere Sprachorgane erzeugen die Vokale wahrscheinlich in derselben Weise durch combinirte Wirkung der oberen und der unteren Stimmbänder, oder dieser letzteren und der Mundhöhle.

Mein Apparat gibt nun wohl die Anzahl der Schwingungen, aber mit weit geringerer Stärke als die der ursprünglichen; wenn auch, wie ich Ursache habe anzunehmen, immer noch bis zu einem gewissen Grade proportional unter sich. Jedenfalls ist aber bei den durchweg kleineren Schwingungen die Differenz zwischen großen und kleinen viel schwerer zu erkennen als bei den Originalwellen, und der Vocal daher mehr oder weniger unbestimmt.

Ob meine Ansichten in Betreff der den Tonverbindungen entsprechenden Curven richtig sind, dürfte vielleicht mit Hülfe des neuen von Duhamel angegebenen Phonautographen (Vierordt, Physiol. S. 254) entschieden werden.

Zur praktischen Verwerthung des Telephons dürfte vielleicht noch sehr viel zu thun übrig bleiben. Für die Physik hat es aber schon dadurch hinreichend Interesse, daß es ein neues Arbeitsfeld eröffnet.

Friedrichsdorf bei Frankfurt a. M.
im December 1861.

(For Tafels I, II, & III see pp.)